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CONTENTS

STANLEY SMYTH FLOWER. By *Malcolm A. Smith* 185

THE EARLY STAGES (EGG, PROLARVA AND JUVENILE) AND THE CLASSIFICATION OF THE CALIFORNIA FLYINGFISH. By *Carl L. Hubbs* and *Elizabeth M. Kampa* 188

Thoburnia hamiltoni, A NEW SUCKER FROM THE UPPER ROANOKE RIVER SYSTEM IN VIRGINIA. By *Edward C. Raney* and *Ernest A. Lachner* 218

NOTES ON THE ARCTIC GRAYLING, *Thymallus signifer* RICHARDSON, FROM GREAT BEAR LAKE. By *Richard B. Miller* 227

ON THE MATING BEHAVIOR OF FREE GARTER SNAKES ASSOCIATED WITH WATER. By *C. M. Breder, Jr.* 236

EFFECTS OF SNAKE VENOMS ON SNAKES. By *Paul L. Swanson* 242

A COLLECTION OF REPTILES FROM HUNAN AND ANHWEI PROVINCES, CHINA. *By Bryan P. Glass* 249

HERPETOLOGICAL NOTES—*Acris* in Mexico and Trans-Pecos Texas, by *M. Graham Netting* and *Coleman J. Goin:* 253.—A New Locality for the Spiny Chuckwalla, *Sauromalus hispidus*, by *Charles E. Shaw:* 254.—Restriction of the Type Locality of *Thamnophis sirtalis*, by *Robert F. Inger:* 254.—Confirmation of Overwintering in Painted Turtle Hatchlings, by *Norman Hartweg:* 255.—Notes on Banded Water Snakes from Georgia, by *Wilfred T. Neill:* 255.—Notes on the Herpetology of Elmore County, Idaho, by *Fred G. Evenden, Jr.:* 256.—An Albinistic Specimen of *Pseudacris feriarum*, by *Joseph F. Ackroyd* and *Richard L. Hoffman:* 257.—An Unusual Habitat for Frogs and Lizards, by *Wilfred T. Neill:* 258.

ICHTHYOLOGICAL NOTES—On Young Western Atlantic Seriolas, by *J. T. Nichols:* 259.—On Taxonomic Questions Related to the Classification of *Barbourisia*, the Cetomimidae and the Iniomi, by *A. E. Parr:* 260.—The Probable Identity of *Neacanthopsis gracilentus* H. M. Smith, *by A. Fraser-Brunner:* 262.—An Interesting Association of Fishes, by *J. L. Baughman:* 263.

REVIEWS AND COMMENTS—Handbook of Lizards: Hobart M. Smith, by *Clifford H. Pope:* 264. Elementary Statistics and Applications: James G. Smith and Acheson J. Duncan, by *C. M. Mottley:* 265.—North American Game Fishes: Francesca LaMont, by *C. M. Mottley:* 265.

EDITORIAL NOTES AND NEWS—Wildlife Conference: 266.—News Notes: 266.—Naturalists' Directory: 266.—A. S. I. & H. Meetings: 267.

INDEX: 267.

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STANLEY SMYTH FLOWER

Stanley Smyth Flower

1871-1946

MAJOR STANLEY FLOWER was one of these rare individuals who, born with a passionate love of natural history, maintained it with unceasing interest until the day of his death at the age of 74. He came of a virile stock and both his parents were descended from men who lived and died in America. His father was the grandson of Richard Flower who founded the city of Albion in Illinois and was a great advocate of freedom of speech, while on his mother's side—Rosetta Smyth—he could claim descent from Captain John Smith, first President of the colony of Virginia. Stanley Flower was the second son of Sir William Flower, Conservator of the Hunterian Collection in the Royal College of Surgeons—during which time Stanley was born—and later Director of the British Museum (Natural History). Thus from his earliest years Stanley Flower began the study of zoology, his nursery the Halls of the College of Surgeons, his playground the Gardens of the Zoological Society close at hand. The knowledge that he gained there of the care of animals was to be of the greatest service to him later on when he went to Egypt.

Flower was educated at Wellington College in Berkshire and at King's College in London. On leaving college at the age of 18 he was given a commission in the Northumberland Fusiliers and was with his regiment for 6 years, serving in India and the Straits Settlements. His army record shows that he was an efficient and hardworking officer, but every hour that he could spare from official duties was given to the study of natural history. He travelled extensively in the Malay Peninsula, collecting and observing, and his first contribution to science, and to herpetology in particular, was published in the Proceedings of the Zoological Society in 1896 "Notes on a collection of Reptiles and Batrachians made in the Malay Peninsula in 1895–1896." His interest in the army never ceased and throughout his life he kept in contact with his regiment and its history, but the dull monotony of army routine could never satisfy him and when in 1896 he was offered the post of scientific adviser to the Siamese Government, he accepted it without hesitation. With his young bride he travelled to Bangkok and took up his residence in what had formerly been the Palace of the Second King, a part of which had been converted into a Museum. He made several expeditions into the interior of the country, travelling by boat, for at that time there were neither roads nor railways. But the pay was poor and often months in arrear, and after two years Flower decided that he could no longer continue the work. When I went to Siam 3 years later the collections that he had accumulated and arranged so carefully were in complete disorder, a heavy storm having blown through the building one night and wrecked everything.

From Siam he went to Egypt, having been appointed by Lord Cromer to take charge of and reorganize the Zoological Gardens at Giza, at that time a very small concern. There he remained for 26 years and there the chief

work of his life was done, his field gradually extending until it covered the whole of Egypt and included the Soudan. He travelled all over the country; he made many journeys to Khartoum by way of the Nile, bringing back animals and birds for the Gardens; he was appointed Ranger of Central Africa and framed the laws for the preservation of game in the Soudan; he instituted the Zoological Survey of Egypt and issued yearly reports on its progress; he founded the Giza Zoological Museum which had its beginning as a small collection in the Gardens; he started the Aquarium at Gezira; he was one of the founders of the Cairo Scientific Society and was its President for two years; he might indeed be called the father of zoological research in Egypt. John Anderson, a great naturalist, was there before him it is true, but he did not build for the country. Flower left monuments behind him that still stand. He took an active part in the preservation of the fauna of Egypt and it was due entirely to his efforts that the egret was not exterminated. For many years these birds had been hunted for their plumage, until by 1912 only two colonies remained in the country. Legislation passed in that year enabled him to protect them so that they began again to multiply, and by 1920 he had the satisfaction of seeing them once again in abundance. It gave him intense pride and pleasure to see these beautiful birds coming in their hundreds at sundown to roost in the trees of the Gardens at Giza.

When the first world war broke out Flower was still on the reserve list of officers and was called on to serve. His knowledge of handling animals was at once made use of, and he was given the work of organizing the Camel Transport Corps, his particular duties being to train officers and men to ride and to care for their beasts, not a simple job for the camel is one of the most wayward and refractory of creatures. He reckoned that during the war some 24,000 animals passed through his hands. He served in the Canal Zone, in Sinai, and in Palestine, and much of the success of the campaign in the last named country was attributed by General Allenby to the efficiency of the Camel Transport Corps. For his services he was given the Order of the Nile, 3rd Class, the Medjidieh, 4th Class, and the O.B.E. When in 1924 Flower retired from his post in Egypt he had served under Lord Cromer, Lord Kitchener, Lord Allenby and Sir Henry MacMahon. Each in their turn had been his intimate friend, and at the Sunday teaparties in the Gardens, where Major and Mrs. Flower kept open house to all their friends, they were constant visitors. Kipling also, when he went to Cairo, always spent a good deal of his time at their house. Lovers of Kipling who remember that delightful story called "Little Foxes" will be interested to learn that it is not entirely fiction but has a strong foundation of truth. Kipling never finished the tale, for he wrote it before the real story ended; Flower finished it for him, and as the account has never been published, here it is. When the Gihon Hunt—which hunted foxes in the Soudan with a pack of English hounds—was finally given up, Flower, rather than see the remaining hounds given over to the tender mercies of the natives, brought them all back to Cairo and had them cared for in the Gardens. How many men I wonder, even had they been lovers of the hunt, which Flower was not, would have done such a thing.

After his retirement from Egypt he settled at Tring—first at Spencer's Green close by—and took an active part in the work of the Zoological Society of London, serving on the Council and representing the Society abroad on several occasions. Zoological Gardens and the care of animals were to him an everlasting pleasure, and he made many journeys over the world for the express purpose of visiting them and comparing them one with another. Before he died he had seen over 80 Institutions and plans to revisit some of the European Zoological Gardens—he hated the word Zoos—were on his programme for this year.

Flower wrote many papers on zoology. Those dealing with herpetology were most numerous, but he contributed others on mammals and birds. For two years he was President of British Ornithologists Union. His papers on "The Duration of Life in Animals" which covered all the vertebrates, began as a card index, and this has been bequeathed to the Zoological Society, to be added to and kept up to date as knowledge grows. He was a good draughtsman both in pencil and in colour. His letters to his intimate friends were often enlivened by marginal sketches to give point to his remarks, and the illustrations in colour that accompany his zoological papers are by his own hand.

But Flower will be remembered by those who knew him not so much by what he wrote and accomplished as by the personality of the man himself; his unfailing courtesy and kindness; his transparent honesty of purpose and his hatred of all mean and petty actions; his delight in the company of his fellow zoologists and the hospitality with which he welcomed them; above all by his passionate love of natural history. He preferred the living creature to the dead, but he did not neglect systematics or forget that the field naturalist, without the systematist to name his specimens correctly for him, would often work in vain. In these days of specialization it was a relief to meet a man who did not specialize; who having at one time cared for and made pets of all the large African vertebrates could in later life be interested in—and moreover make pets of—woodlice, centipedes and snails. He always claimed that his pet woodlouse knew him from other people and would come out of hiding when he put his hand into its cage.

His interest in his fellow naturalists induced him to compile a directory of zoologists, a book in which, starting with Aristotle, B.C. 384, every person who had done work in zoology should be recorded. At what time he began it I do not know but it was being continually added to up to the time of his death. It now includes more than 3500 names and has been presented, at his request, to the Linnean Society. It is naturally very incomplete, but it is a useful start to a work that is badly needed.

Flower married twice. His first wife was Sibyl Wallace by whom he had 4 children, two sons and two daughters. In 1939 he married Dorothea Stewart who survives him.—MALCOLM A. SMITH, *British Museum (Natural History), London, England.*

The Early Stages (Egg, Prolarva and Juvenile) and the Classification of the California Flyingfish [1]

By Carl L. Hubbs and Elizabeth M. Kampa

With aid from several colleagues we have obtained and have described the egg and the prolarval and juvenile stages of the California flyingfish and have brought these and other pertinent data to bear on the classification of *Cypselurus californicus* and other species. We are particularly indebted to George S. Myers of Stanford University, who has generously supplied us with specimens and with the conclusions that he and Charles B. Wade have reached in their unpublished revision of the Exocoetidae of the eastern Pacific. Charles M. Breder, Jr., of the American Museum of Natural History, has given us the benefit of his extensive knowledge of synentognathous fishes and their development and has very helpfully criticized our manuscript. In the absence of William Beebe, John Tee-Van placed at our disposal eggs and adults of flyingfishes that were collected on the Zaca Expedition of 1936, along with the field notes. The authorities of the United States National Museum granted like privileges. Margaret Storey of Stanford University and Irene McCulloch of the Allan Hancock Foundation of the University of Southern California and W. I. Follett of Oakland have further assisted in supplying material for study. Reeve M. Bailey of the University of Michigan Museum of Zoology has sent specimens and has made fin-ray counts. Herbert Mann collected for us the juvenile flyingfish which has proved to be of great value in our study. Laura C. Hubbs helped to collect specimens, has made some statistical calculations and has otherwise helped in the preparation of this report.

Egg

The egg attributed to *Cypselurus californicus* by Barnhart (1932: 91, fig. 2) and by Beebe (1938: 216–220, 302) is now found to represent another species. It differs strikingly from the mature ovum of *C. californicus* in having the adhesive filaments more close-set and confined to two poles instead of being uniformly distributed over the entire egg. Though the filaments cover a much smaller proportion of the egg surface they are almost as numerous: Barnhart counted 18 to 28 at each pole and the few counts we have made on his material lie within these limits, whereas in *C. californicus* we find the number to approximate 60. Most of the filaments at one pole are much coarser than those at the opposite pole (a point overlooked in the published description). In *C. californicus* the diameters of the filaments are approximately uniform. The egg described by Barnhart is larger than that of *C. californicus*. The diameter was measured by Barnhart as 2.2 mm., and we confirm this figure by determining the diameter of 10 of the eggs (shrunken in alcohol) to be 1.9 to 2.2 mm., averaging 2.02 mm. In contrast we find that 27 ova of *C. californicus* measure 1.57 to 1.70 mm., averaging 1.64 mm., in diameter. We have found no other report of a cypselurine egg larger than 2.0 mm. The nearest approach is provided by *Cypselurus* (*Hirun-*

1 Contributions from the Scripps Institution of Oceanography, New Series, No. 298. The cost of publishing this article has been partially defrayed by The Special Publication Fund and by the Scripps Institution.

dichthys) *speculiger,* which has an egg diameter of 1.9 mm. (Bruun, 1935: 73).

The flyingfish eggs described by Barnhart were taken from an egg mass, with a volume of about one pint, found on July 1, 1931, in the surf near La Jolla. Some of the larvae that hatched from these eggs in an aquarium were raised for ten days, to a stage advanced far enough to make it certain that the species is a member of the Cypselurinae, but not far enough to permit specific identification.

The egg and larval characters, however, suffice to show that the species treated by Barnhart is not identifiable with any of the flyingfishes which have been recorded from the general vicinity of La Jolla. As already indicated the identification with *Cypselurus californicus* was incorrect. Identification with *Prognichthys* (*Danichthys*) *rondeletii* also seems to be excluded. In the first place, the egg of *P. rondeletii,* according to D'Ancona (1931: 165, 177, pl. 10, fig. 1), has 40 to 45 uniformly distributed filaments and measures 1.4 to 1.5 or 1.72 mm. in diameter. In the second place, the ten-day larvae already have the second pectoral ray long and branched (the character that distinguishes *Cypselurus* from *Prognichthys*). It is also obvious that the species dealt with by Barnhart is not *Fodiator acutus,* for the egg of that species has a diameter of 1.40 to 1.70 mm. and bears about 18 uniformly distributed filaments (Breder, 1928: 16, fig. 7; 1938: 16, fig. 7).

Prognichthys (*Danichthys*) *rondeletii* (Valenciennes) was recorded by Higgins (in Thompson and Higgins, 1919: 95), under the name of *Exonautes rondeletii,* from "150 miles off San Diego." The one specimen, now in the University of Michigan Museum of Zoology (No. 94695), has been re-examined by courtesy of Dr. Reeve M. Bailey. It was collected 150 miles southwest of San Diego, hence south of the extension of the international border. It agrees well with Bruun's characterization of the species (1935: 73–77, pl. 7, figs. 2, 4). The first and second pectoral rays are unbranched and these rays and the two branches of ray 3 are graduated in length. The ray counts are: D 10 and A 11 (counting last two elements as one ray); P_1 18—18; P_2 6—6. The predorsal scales number 29; those between the dorsal origin and the lateral line, 6 or 7. The pectoral fin is dark with the posterior edge pale. No teeth are apparent on the palate.

Fodiator acutus has been reported from California by Walford (1931: 402, fig. 108) and by Barnhart (1936: 23, fig. 78). The Pacific subspecies was described as *Fodiator acutus pacificus* by Bruun (1933: 378; 1935, 20–22) and by Breder (1938: 13–14, figs. 6–7), despite the fact that it was recognized as having been named twice previously, first as *Exocoetus rostratus* by Günther (1866: 280) from the Sandwich (Hawaiian) Islands, and second as *Hemiexocoetus caudimaculatus* by Fowler (1901: 293–294, 1 fig.), on the basis of a beaked young from Mazatlán, Mexico. The apparently proper designation *F. a. rostratus* has recently been used by Fowler (1944: 407–408, 491, fig. 111). *Hemiexocoetus caudimaculatus* has been recognized as the juvenile stage of *Fodiator acutus* by Nichols and Breder (1928: 426, fig. 157), Bruun (1935: 22), Hubbs (1933: 606), Breder (1938: 12) and Fowler (1944: 408). Incidentally, it may be noted that David (1946: 59–61, fig. 4, pl. 2, figs. 1–2, pl. 3, fig. 1) has just proposed

the preoccupied name *Hemiexocoetus* for a genus of supposedly synentognathous fishes known only from fossil scales found in the Kreyenhagen ("Eogene") formation of California.

Suspecting that the eggs and larvae described by Barnhart might belong to a recently recognized Californian species to be described by Myers and Wade (MS), we examined the three adult types of that species in the Stanford University collection by courtesy of Dr. Myers. One proved to be a female containing maturing eggs on which the filaments are tightly wrapped in a zigzag pattern around the surface. On close inspection, however, it was possible to distinguish the bases of the filaments, and these proved to be confined to the two poles with most of those at one pole coarser than those at the other. Furthermore, the number of bases corresponded approximately with the filament counts given by Barnhart. It seems almost certain, therefore, that Barnhart dealt with the new species.

On a similar inference we re-examined the flyingfish eggs that were briefly described by Beebe and referred by him to *Cypselurus californicus*. These also proved to represent the species to be named by Myers and Wade. The eggs that were first described by Beebe were taken from a flyingfish that was collected (in the stomach of a Brewster booby) on May 8, 168 miles southwest of Cape San Lucas. These eggs average less than 2.0 mm. in diameter, though the major diameter of some elliptical ones is as great as 2.3 mm. The lesser diameter is as small as 1.5 mm. The average diameter is not far from 1.7 mm., but if the eggs had been laid they would probably have absorbed enough water to swell to an average diameter in excess of 2 mm. The eggs have the filaments crowded in two polar clusters, as Beebe recorded in manuscript along with the notation that they were pale orange in color. The adult was not saved, but the fin-ray counts (D 14, A 10) and the fin-base measurements (D 60 mm., A 44 mm.), as recorded in the field, suffice to show that the species was not *C. californicus*.

The eggs reported by Beebe (1938: 219) as having been taken in sargassum "50 miles farther south, nearer Clarion" are also referable to Myers and Wade's species rather than *C. californicus*. These eggs (in two clusters) were actually taken in kelp (*Macrocystis pyrifera*) at 5:30 P.M. on May 17, 173 miles north of Clarion Island, at 21° 12′ N. Lat., 115° 11′ W. Long. The fact that the kelp was accompanied by a kelp blenny (*Heterostichus rostratus*) indicates that it had floated southward from the west coast of Baja California. The eggs in the two groups had been deposited at different times. Those in one lot were in a very early stage and, like ripe ovarian eggs, still averaged only about 1.7 mm. in diameter with none as large as 2.0 mm. The eggs of the other cluster contained advanced embryos and slightly exceeded 2.0 mm. in diameter. The eggs of both lots had filaments crowded in two polar clumps. On the average they correspond well with the eggs described by Barnhart. They show considerable variation however. In some eggs the two clusters are not opposite, and rarely may be separated by an angle as small as 100°. The two polar clusters on one egg may differ markedly in size and in number of threads. Rarely a group covers nearly half a hemisphere, or may be reduced to a very small area. The number of filaments per cluster varies well beyond the limits given by Barnhart.

An adult female of the new species, with ripe eggs having bipolar filaments, flew on board the "Zaca" at night on May 20, 1936, 120 miles north of Alijos Rocks, off the west coast of Baja California, along with a *C. californicus* male that was not fully ripe. This observation confirms other indications that the new species spawns earlier in the year than *C. californicus*.

Embryo-containing eggs of the true *Cypselurus californicus* (Pl. I, figs. 3–4) were developed in the laboratory. The eggs were originally obtained by stripping an adult female and were fertilized by the sperm of an adult male. These fish were dip-netted with 23 other ripe adults beneath a light during the night of August 4-5, 1945, at the end of the pier of Scripps Institution of Oceanography, near La Jolla, California. Eggs with similar filaments were removed from the ovaries of other females of this species. The eggs from the female stripped on August 5 are uniform in size and structure. The diameters of 27 ova, as measured by an ocular micrometer calibrated against a stage micrometer, vary from 1.57 to 1.70 mm., with an average of 1.64 mm. The filaments, numbering about 60, are distributed rather uniformly over the whole surface, leaving no large areas bare. The distance between the bases, however, is not constant. In 18 determinations the intervening distances range from 109 to 430 μ, with an average of 274 μ. The base of each filament (Pl. I, fig. 4) is somewhat swollen in the form of a truncated cone and appears less homogeneous than does the main part of the filaments. Under appropriate magnification and lighting a cross-line is visible between the base and the filament proper, but whether this line represents an internal suture or merely a superficial fold is not certain. The thicker end of the base is attached to the egg by a swelling shaped like an inverted saucer.

The very distinct types of ova of the two species of *Cypselurus* now known from California find approximate counterparts in the wide ranges of egg structure characteristic of other synentognathous fishes. In the following key these two types are compared with the eggs of other species, as described in the references cited.

Key to Egg Characters of Synentognathous Fishes

1a.—Egg without trace of spines or filaments (subfamily Exocoetinae; genus *Exocoetus*).

2a.—Egg diameter 1.7 to 2.0 mm.—*Exocoetus volitans* (Bruun, 1935: 33; Breder, 1938: 30).

2b.—Egg diameter 2.8 to 2.9 mm.—*Exocoetus obtusirostris* (Bruun, 1935: 40; Breder, 1938: 33–34).

1b.—Egg with short spinelike processes, uniformly distributed (Oxyporhamphinae).—*Oxyporhamphus m. micropterus* (Delsman, 1924: 410–411, figs. 1–2) [2]; *Oxyporhamphus m. similis* (Bruun, 1935: 19–20, fig. 3).

1c.—Egg with long adhesive filaments.

3a.—Filaments distributed over entire surface of egg.

4a.—Egg diameter exceeding 2.3 mm. (Belonidae and some Hemiramphidae).

5a.—Filaments rather evenly distributed over surface of egg.—*Belone belone* Häckel, 1855: 23–31, pl. 1 and pl. 2, fig. 7 [3]; McIntosh and Masterman, 1897: 400–401, fig. 40; Ehrenbaum, 1904: 177–179, pl. 6, figs. 61–63; Cunningham, 1912: 327–328, pl. 27; D'Ancona, 1931: 161, pl. 8, fig. 1;

2 Delsman favored the view that this egg belonged to a species of *Hemiramphus* and Breder (1938: 9, fig. 2) was not certain that it should be referred to *Oxyporhamphus*, but other descriptions of the eggs of the two genera leave almost no doubt that Delsman had the ovum of *Oxyporhamphus*.

3 Häckel (1855: 24–27, pl. 5, figs. 11, 14) pictured an ovarian egg of *"Tylosurus"* as having elongated filaments scattered over the egg surface.

Job and Jones, 1938: 245–246); *Tylosurus*[4] *marinus* (Ryder, 1882: 284–285, pl. 19); *Tylosurus melanotus* (Delsman, 1924: 408); *Tylosurus strongylurus* (Job and Jones, 1938: 246–249, figs. 1–2); *Hemiramphus far* (Smith, 1933: 136).[5]

5b.—Filaments distributed over the surface of the egg but more concentrated and longer at one pole than elsewhere.—*Tylosurus notatus* (as figured by Breder, 1932: 4, fig. 1; 1938: 110).

4b.—Egg diameter less than 2.3 mm.

6a.—Filaments 4 (Hemiramphidae in part).

7a.—Egg diameter about 1.5 mm.—*Hemiramphus georgii* (as figured by Devanesen, 1937: 2177–2178, fig. 3).

6b.—Filaments more than 10 but fewer than 20 (Fodiatorinae).

7b.—Egg diameter 1.4 to 1.7, average 1.53 mm.—*Fodiator acutus rostratus* (as figured by Breder, 1928: 16, fig. 7; 1938: 16, fig. 7).

6c.—Filaments in intermediate number, about 38 (Parexocoetinae).[6]

7c.—Egg diameter 1.3 to 1.4, average 1.35 mm.—*Parexocoetus brachypterus littoralis* (as figured by Breder, 1932: 20, pl. 8, 2 figs.; 1938: 23, 25, fig. 12).

6d.—Filaments numerous, more than 45 (Cypselurinae, in part; Hemiramphidae, in part).[7]

7d.—Egg diameter 1.2 to 1.45, average 1.28 mm.; filaments figured as about 114 (57 on one hemisphere).—*Cypselurus* (*Cypselurus*) *comatus* (Breder, 1927: 21, fig. 10C; 1938: 52, fig. 27).

7e.—Egg diameter 1.4 to 1.5 mm.; filaments described as about 90 to 100.—*Prognichthys* (*Danichthys*) *rondeletii* (D'Ancona, 1929: 208; 1931: 165, pl. 10, fig. 1).

7f.—Egg diameter about 1.6 mm.; filaments not described in detail.—*Cypselurus* (*Cypselurus*) *lutkeni* (Bruun, 1935: 58); *Hemiramphus krysnaensis* (Smith, 1933: 146–147).[8]

7g.—Egg diameter 1.57 to 1.70, average 1.64 mm.; filaments about 60.—***Cypselurus (Cheilopogon) californicus*** (original data).

7h.—Egg diameter 1.6 to 1.8, average 1.7 mm.; filaments about 54.—*Cypselurus* (*Cypselurus*) *heterurus* (Breder, 1927: 20, fig. 10A).[9]

3b.—Egg with one long stout filament at one pole, a tuft of 7 to 16 minute ones at opposite pole and 4 to 6 others of medium size.

7i.—Egg diameter 1.7 to 1.8 mm.—*Cypselurus* (*Hirundichthys*) *coromandelensis*[10] (Ramaswami Nayudu, 1923: 109).

3c.—Egg with one especially strong filament at one pole and a cluster of 10 to 20 long filaments at the opposite pole. Egg often elliptical.

7j.—Egg diameter 1.48 to 1.86 mm.—*Cypselurus* (*Cypselurus*) *heterurus* (Raffaele, 1895: 128–129; 1898: 334; Lo Bianco, 1909: 716; Fage, 1910: 22, figs. 23–24; Neppi, 1921: 39–40, pl. 1, fig. 1; D'Ancona, 1929: 207–208; 1931: 168, pl. 10, figs. 12–13).[9]

3d.—Egg with filaments restricted to two clumps at opposite poles.

7k.—Egg diameter 1.5 to 1.67 mm.; 7 to 12 mostly thicker, longer filaments at one pole and 12 to 21 thinner and shorter threads at the other

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4 We hold in abeyance the problem of the nomenclatorial and systematic status of *Strongylura*. Ryder used the name *Tylosurus longirostris* for the species now known as *Tylosurus marinus* or *Strongylura marina*.

5 Devanesen (1937: 2178) gave the egg diameter of *H. far* as only 2.2 mm.

6 It should be noted, however, that, on the basis of preserved material, Breder (1927: 19–20, fig. 10B) figured an egg of "*Parexocoetus mesogaster*" as having short and very numerous filaments (95 drawn on one hemisphere).

7 That *Prognichthys* (*Prognichthys*) *gibbifrons* and a related Pacific species have eggs of this general type is indicated by Bruun (1935: 67, 83).

8 Ovarian eggs of the same general type were incompletely described by Häckel (1855: 24–27) for three species of *Hemiramphus* (*marginatus, commersonii* and *far*).

9 There is confusion regarding the eggs of species identified as *heterurus* (see also p. 195). In their accounts of *Exocoetus heterurus* Neppi and D'Ancona both referred to descriptions of the egg by Häckel (1855: 23–27) and Emery (1878: 44–45). Häckel's figure looks like the "*heterurus*" described by Breder and there is nothing in Emery's description to indicate that he had an egg with a specialized distribution of filaments.

10 The genus and species to which this peculiar egg belongs are uncertain. Our very tentative identification is made on the basis of description and remarks by Hornell (1923: 107–108).

pole.—*Cypselurus* (*Hirundichthys*) *affinis* (Möbius, 1894[11]; Bruun, 1935: 69; Gudger, 1937: 373–375[12]; Breder, 1938: 79).

7l.—Egg diameter about 2.2 mm.; typically 18 to 28 long filaments at each pole, mostly coarse at one pole and all fine at other.—***Cypselurus (Cypselurus), new species*** (Barnhart, 1932: 91, fig. 2).

3e.—Egg with filaments confined to one pole of the egg (Scomberesocidae, in part).

7m.—Eggs spherical to elliptical, 1.53 to 1.76 × 1.58 to 1.89 mm. in diameter.—*Cololabis saira* (Nakamura, 1937: 18, figs. 1–2).[13]

Clearly the eggs of the Exocoetidae as well as those of other Synentognathi show marked differences in diameter and in the number, size and distribution of the adhesive filaments. The taxonomic significance of the size and structure of the eggs of these fishes has received considerable attention and the data were summarized by Breder (1938: 107–112). Sufficient attention, however, has not been accorded the phylogenetic import of such specializations of the filaments as are emphasized in the preceding key.

Parallel distinctions are exhibited by the eggs of the Atherinidae (Hubbs, 1921: 271–272; Hubbs and Raney, 1946: 23–24). In that family as in the Exocoetidae, the filaments are lacking in some species. When present they are confined to a tuft at one pole, but vary greatly in number and length. In some species, one of the filaments is much enlarged and in *Labidesthes* only a single very long adhesive thread is developed.

Larvae

The larvae of *Cypselurus* that Barnhart reared from the eggs collected near La Jolla are not comparable with the few available prolarvae[14] (Pl. I, figs. 1–2) of *C. californicus*. The latter were hatched about August 15, 1945, perhaps prematurely, from the eggs that were artificially fertilized on August 5, 1945. The larvae figured by Barnhart (1932: 91–92, figs. 4–6) were 1, 5, and 10 days old, respectively, and all are at a much more advanced stage than are any of our specimens. Even his 12-hour specimens, which were not figured, are definitely larger than the *C. californicus* prolarvae. In total length they range from 5.5 to 7.4 and average 6.26 mm., rather than from 4.1 to 4.8, with an average of 4.45 mm. (in six specimens of each). They are also further developed in head and fin structures. Our specimens are at a less advanced stage of development either because they were prematurely hatched or because they were derived from a smaller egg. It is a general rule that the stage at which a fish hatches is positively correlated with the size of the egg.

On comparing Barnhart's 12-hour examples with our specimens, which died very soon after hatching, certain differences appear, in addition to the larger size and the less embryonic form. In the first place, the dorsal fin begins far in advance of the anal, instead of only slightly farther forward,

11 Möbius thought it probable that the eggs which he described were those of the sargassum fish, *Pterophryne* (=*Histrio*).

12 Gudger, who based his account on the observations of Möbius, definitely showed that the eggs were those of some flyingfish.

13 The egg of *Scomberesox rondeletii* according to Häckel (1855: 24–27, pl. 5, figs. 8, 15) has long filaments that appear to be scattered over the whole surface, though Häckel's description of the ovarian egg is inconsequential and his figure is not clear on this point. Raffaele (1895: 127–129) claimed that the large egg of this species ("oltre a 2 mill. di diametro") is wholly devoid of filaments, and could not explain the discrepancy between his observations and Häckel's. D'Ancona (1931: 161) also discussed this question.

14 The larvae of fishes may be distinguished as prolarvae and postlarvae (Hubbs, 1943). The prolarval stage persists until the yolk is completely absorbed.

and the dorsal fin has a longer base. These relations, which persist in the 5- and 10-day larvae, indicate that Barnhart's fish is a member of the subgenus *Cypselurus*. Identification with the genus *Prognichthys* is precluded by the branching of the second pectoral ray in the 10-day larvae. In the older larvae it is possible to make approximate counts of the fin rays. These vary from 12 to 14 in the dorsal fin, and from 9 to 11 in the anal with a difference of from 1 to 5 rays. In these respects, as in others, Barnhart's species differs from *C. californicus* (see Tables I and IV). In the second place, most of Barnhart's specimens, unlike ours, show a more or less continuous fine black streak along the axial septum of the body wall muscles. Thirdly, the longitudinal rows of melanophores appear to be somewhat less even than in the prolarva of *C. californicus*. In all these characters, except that of the axial streak, larvae newly hatched from the eggs collected by Beebe on May 17 agree with Barnhart's samples.

Too few flyingfishes have been described in the larval stages to warrant an attempt to identify, on the basis of larval characters, the species that was described by Barnhart. Marked differences in the positions and proportions of the fins and in pigmentation become apparent when his descriptions and figures (1932: 91–93, figs. 4–6) are compared with data for *Parexocoetus brachypterus littoralis* published by Hildebrand and Cable (1930: 446–452, figs. 60–67) and by Breder (1932: 20–21, pl. 8; 1938: 23–25, figs. 10–11). In the form of the body and in the relative positions of the dorsal and anal fin origins this larva contrasts with the comparable stages of *Exocoetus volitans*, as described by Roule and Angel (1930: 80–84, pl. 4, figs. 104–109) and, second-hand, by D'Ancona (1931: 173–176, figs. 162–166). The pigmentation, however, is rather similar. At like stages the larva treated by Barnhart differs from that of *Prognichthys* (*Danichthys*) *rondeletii*, as described by D'Ancona (1931: 165–168, 176–177, pl. 10, figs. 2–7)[15] in the slenderer body, the more anterior origin of the dorsal fin in comparison with the front of the anal, and the much less conspicuous light band on the caudal peduncle. Both Californian species as well as *P. rondeletii* are much more sparsely pigmented in the early larval stages than is *Cypselurus heterurus* (as treated by D'Ancona, 1931: 169–173, pl. 11). This is particularly true of the larvae up to 7 mm., for at that length the melanophores on the sides of *C. heterurus*, as figured, are confined to a series along the mid-side of the anterior half of the body.

The early prolarva (or prematurely hatched advanced embryo) of *Cypselurus californicus* is very heavily pigmented (Pl. I, figs. 1–2). When expanded the melanophores are so large that the dendrites of adjacent pigment cells approach one another and on the upper part of the body actually intertwine. The eye is densely pigmented with small melanophores. On the top of the head the black color cells are about as large as on the body but are more irregular in branching and outline and are not definitely aligned. Those forming the last pair on the head are transitional toward those on the body. There follow four pairs of particularly large pigment cells. These in turn are followed along the mid-dorsal line by seven similar cells, which extend to a short unpigmented streak directly in front of the dorsal fin.

[15] The larvae described by Emery (1878: 44–45, pl. 1, figs. 7–9) may have been *P.* (*D.*) *rondeletii*.

About 26 paired melanophores, decreasing in size posteriorly, extend from the mid-dorsal seven to the base of the caudal rays. Between the dorsal and anal fins there are 6 regular rows, of which the upper 4 extend forward along the trunk. On the lateral surface of the yolk-sac the arrangement is less regular. The lower surface of the yolk-sac is unpigmented except for a group of small melanophores in the region of the heart. Similar pigment covers the surface between the eyes ventrally and anteriorly. There are two or three black specks on the pectoral base and there may be two on the fin. Very small melanophores are scattered over the interradial membranes of the caudal fin but there are none on the dorsal, anal or pelvic fins.

At the stage figured the pectoral fin extends half-way from its axil to the end of the pelvic base. The pelvic fin is inserted about half as far from the anal origin as from the pectoral axil. The dorsal and anal fins originate at about the same vertical. The distance between the dorsal origin and the base of the middle caudal rays is contained 1.6 times in the predorsal length. The dorsal and anal fins are each connected with the caudal by a fin-fold that increases in height posteriorly. The caudal rays are conspicuous finger-like structures which end abruptly well within the margin of the fin. The outline of the caudal is obliquely rounded with most of the posterior edge sloping downward and forward. The hypural cartilage is conspicuous. The lepidotrichia of the anal fin are becoming apparent while the rays in the dorsal have not distinctly passed the ceratotrichial stage. The definitive rays of the paired fins are just beginning to show. The depth of the body is little more than one-seventh the standard length. The mouth is still inferior and embryonic in appearance.

The prolarva of *Cypselurus californicus* differs from the few descriptions we have found of the corresponding stages of other species. Comparison has already been made (pp. 193–94) with the other California species. The contrast with the prolarvae of *Parexocoetus* and *Exocoetus* (references on p. 194) is too sharp to require special discussion. In its nearly complete pigmentation the *C. californicus* prolarva is strikingly unlike the early larva of *C. heterurus,* which according to D'Ancona (1931: 169, pl. 11, fig. 1) is characterized by a dearth of melanophores. The early stage attributed to *"Exocoetus volitans"* (= *C. heterurus*) by Neppi (1921: 40, pl. 2, fig. 2) is, in contrast, heavily pigmented, but the identification was doubted by D'Ancona. There has obviously been some confusion regarding the species which have been identified as *heterurus,* for two types of eggs (p. 192) as well as two types of larvae have been attributed to this species. A further contrast between the larva of *C. californicus* and that of *C. heterurus* as figured by D'Ancona lies in the relative position of the dorsal and anal origins. When compared with the prolarva of *Prognichthys rondeletii* as described by D'Ancona (1931: 165, pl. 10, fig. 4), the corresponding stage of *C. californicus* is seen to be slenderer and to be more heavily pigmented on the caudal peduncle.

Although the larval characters have been described for only a few species of flyingfishes, it seems probable, from the comparisons just made (as well as from the general rule that early stages of even related fish species exhibit differences), that the larvae of many if not all exocoetids will prove identifiable. In all probability the prolarva of *Cypselurus californicus* can be dis-

tinguished on the basis of the present description and figures from like stages of all other Californian fishes. Of the few larvae described to date from California that of the flounder *Pleuronichthys coenosus* is seen from the account by Budd (1940: 35, pl. 9) to be somewhat similarly pigmented, but to be very different in that most of the overall depth is made up of expansive fin-folds. Other species of *Pleuronichthys* and of the additional genera treated by Budd are less extensively pigmented.

Juvenile

A juvenile stage as well as eggs and larvae has been ascribed wrongly to the California flyingfish. Jordan and Starks (1907: 68, fig. 2) identified as *"Cypsilurus californicus"* a three-inch specimen from Avalon, Santa Catalina Island, California. This specimen (No. 9954, Natural History Museum of Stanford University) has been re-examined by courtesy of Dr. George S. Myers. It is certain that this young fish is not *Cypselurus californicus*. It is more robust than the adult of that species, rather than more slender as would be expected if it were the young of *C. californicus*. The scales (imperfectly shown in the figure) are far too large, and number about 33 rather than 42 to 47 between the dorsal fin and the occiput. The dorsal fin has a longer base and originates farther forward, about 2.3 instead of about 3.0 times as close to the caudal base as to the tip of the snout. In the number of dorsal and anal fin rays (D 11, A 10) this specimen, perhaps extreme for the species in this respect, agrees with *C. californicus*. This juvenile is referred by Myers and Wade (MS) to their new species. It seems, therefore, to be of the same species as the eggs and larvae that were described by Barnhart.

A somewhat larger juvenile of the new species, 92 mm. in standard length, displays a sharp difference between this form and *C. californicus* in the structure of the barbel. It was collected by Elmer Higgins on October 6, 1918, after it had flown on board the "Albacore" at night about 150 miles southwest of San Diego. This specimen, now in the University of Michigan Museum of Zoology, was examined by courtesy of Dr. Reeve M. Bailey. The subcylindrical stump of one of the paired barbels, with a fringe on its outer base, remains, but the barbel of the other side has been lost, leaving a very shallow scar. In other characters this specimen agrees with the new *Cypselurus* and differs from *C. californicus*. Head length, 4.8; body depth, 6.7; orbit in head, 3.1; least interorbital width, 1.1 in orbit; distance from dorsal origin to caudal base, 2.3 in predorsal length. The predorsal scales number about 34. The scales in the lateral series, about 54. There are 12 dorsal and 10 anal rays.

Plate I (opposite page)

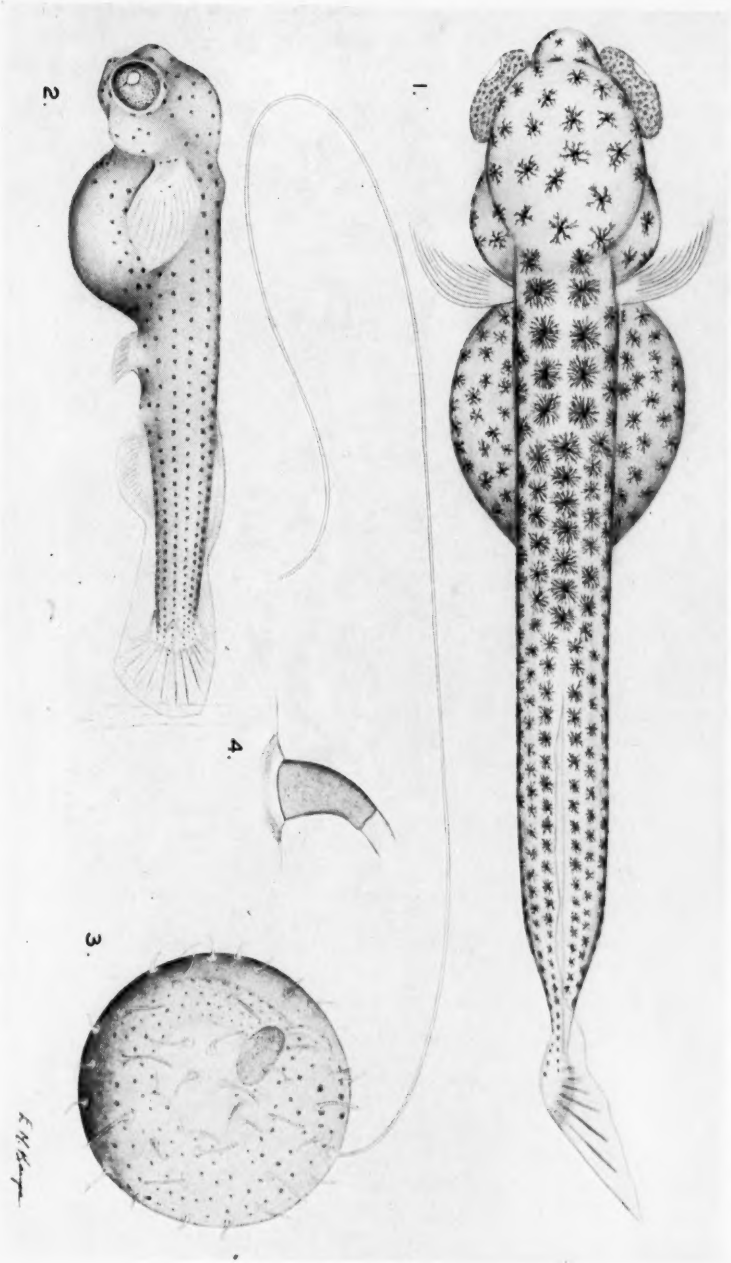
Egg and prolarva of *Cypselurus californicus*.

Fig. 1. Newly hatched prolarva in dorsal aspect, showing details of pigmentation. Length about 4.5 mm.

Fig. 2. Prolarva in lateral view.

Fig. 3. Embryo-containing egg showing one complete filament and bases of others. Diameter about 1.65 mm.

Fig. 4. Base of a filament, showing detailed structure.



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A juvenile flyingfish (Figs. 1–3) that is really referable to *Cypselurus californicus* is now at hand. This fine example, 69 mm. in standard length, was collected on September 26, 1945, by Herbert Mann. He took it with a dip-net under a light off the "E.W. Scripps," in the Pacific Ocean 20 miles west of San Diego Harbor, at 32°36′ N. Lat., 117°35′ W. Long. The depth was determined as 620 fathoms and the surface temperature as 70° F. Nine young specimens of the Pacific saury, *Cololabis saira* (Brevoort), were taken with the young flyingfish.

The fin ray counts are: D 10 and A 10, counting the last two elements as one ray; P_1 i, 10, iv—i, 10, iv, totalling 15—15; P_2 6—6. The lateral scale rows number about 66 and the predorsal rows (occiput), 47. The same and similar ray counts were obtained on adults identifiable as *C. californicus* (Table I). The very high scale counts are even more diagnostic of that species. The distance between the dorsal origin and the anteriormost upper

TABLE I

DORSAL AND ANAL RAY COUNTS OF *Cypselurus californicus*

Number of rays	9	10	11	12	No.	Mean	SE
Dorsal ray counts	1	23	80	12	116	10.89	.05
Anal ray counts	24	74	17	..	115	9.94	.06

procurrent caudal ray is a little less than one-third the length forward to the tip of the snout—another diagnostic feature of *C. californicus*, as determined by Myers and Wade (MS). The anal origin lies between the verticals from the third and fourth dorsal rays. In the adult of *C. californicus* the anal origin lies below the third to fifth dorsal ray.

This young flyingfish differs from the adult of *Cypselurus californicus* in several very notable features, which we interpret as the juvenile characters of the species. Most striking is the relatively immense semicircular barbel (Figs. 1–2 and, in more detail, Fig. 3), which projects from the mandible and is incised nearly to the base so as to form about 14 more or less fimbriate ribbons. The two processes forming the last pair are shorter and are more complexly divided than the others. The long fimbriae hang from a saclike structure that envelopes the entire upper surface as well as the outer border of the lower face of the mandibular projection. This part of the lower jaw is triangular and protrudes beyond the mouth a distance about half as great as the width across the premaxillaries. The basal saclike structure has a large dorsal and a small ventral cavity which interconnect except along the midline anteriorly. Here the membranes are attached to the tip of the mandible so as to form a short frenum which extends downward and forward across the base of the barbel. When the barbel is extended forward (in the preserved specimen it is easily floated into this position) its length from the tip of the premaxillaries equals about half the distance backward to the pectoral insertion. In life the barbels were held forward and slightly downward (at about 30° with the horizontal) as the fish swam rapidly in a bucket.

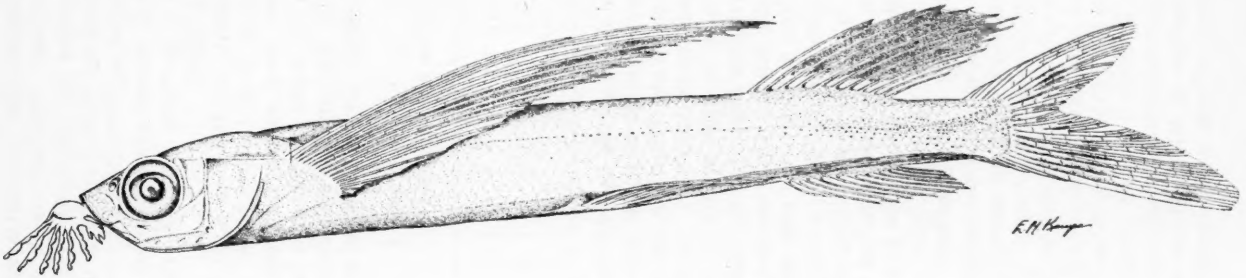
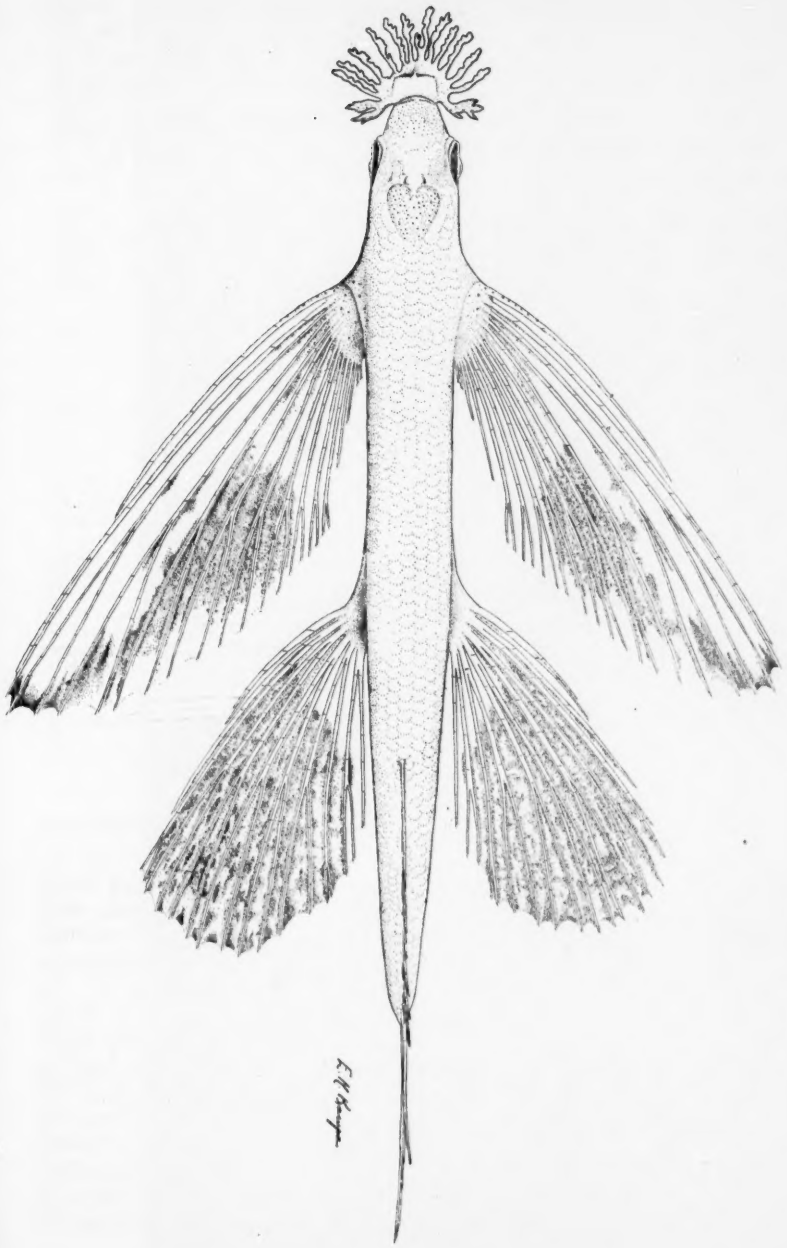


Fig. 1. Juvenile of *Cypselurus californicus* in lateral view, from a specimen 69 mm. in standard length, taken off San Diego, California.

Fig. 2. (On opposite page). Juvenile of *Cypselurus californicus* in dorsal view, from the same specimen.

In both figures the squamation of the head is sketched from adults. The cross bars on the body (p. 198) had faded before the drawings were completed.



Another feature interpreted as a juvenile character is the greatly elevated dorsal fin. The sixth and longest ray is about one-half longer than the base of the fin. When folded backward this ray reaches nearly to the fork of the caudal fin. The following rays become abruptly shorter, whereas the preceding ones are graduated to the first, which is a little longer than the fin base. The anal fin somewhat resembles the dorsal in shape, but is much lower. Its longest ray is little more than half as long as the sixth dorsal ray.

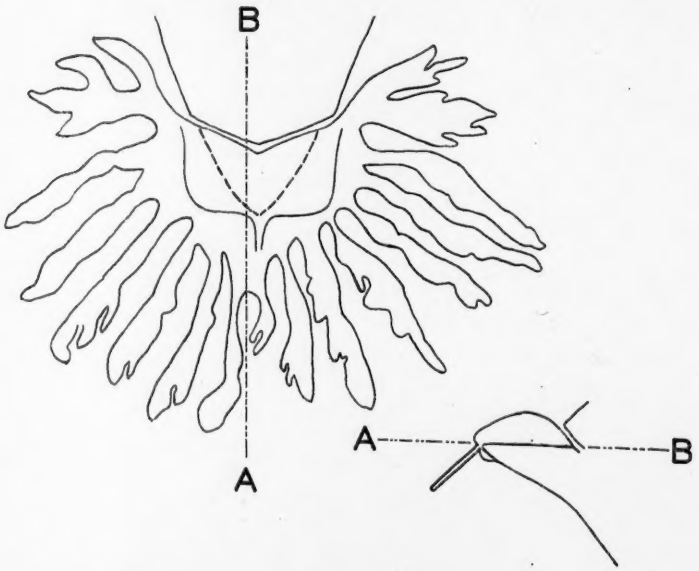


Fig. 3. Barbel of 69-mm. juvenile of *Cypselurus californicus*.
Diagram in dorsal aspect with fimbriae in horizontal position. Including sagittal section through line A—B. Enlarged about 9 times.

The juvenile color pattern is also very striking. The markings on the "wings" (Fig. 2) are particularly impressive. Instead of being dusky with light posterior edging, as it is in the adult, the pectoral fin is largely clear with a prominent sooty blotch on the outer part between the fifth and ninth rays. From this blotch a submarginal band extends to the tip of the fin. The pelvic is blackish in the axil and is sooty over most of the rest of the fin, with an irregular clear stripe intervening. Toward the tip the pelvic fin becomes blotched with light and dark. The dorsal is clear at the base but over most of the surface it is largely sooty, and somewhat dappled. The margin is whitish at the tip of the lobe. Most of the caudal is clear but there is a large dark area near the middle of the lower lobe and a smaller dark blotch farther out. Across the belly, about midway between the pectoral and pelvic fins, there lie two dark bars, set rather close together and made up of large melanophores. A similar but less regular bar extends across the

belly just before the pelvic fins and a trace of another bar passes between the posterior ends of the pelvics. Before the anus there is a large median blotch of small melanophores and a similar mark is situated below each pectoral fin. Black specks are scattered down the midline of the belly. Otherwise the ventral surfaces are largely clear of pigment. An axial file of melanophores on the side is paralleled anteriorly by a less regular row. Posteriorly the axial row of dots becomes a dark streak. A regular triple row of melanophores extends from the dorsal fin to the parietal blotch and lines of pigment specks run downward and forward along the myocommata. The barest trace of about six dorsal saddles is discernible. The top of the muzzle is finely punctulate and the opercles are coarsely punctate. The fimbriae of the barbel are edged with dusky.

TABLE II

COUNTS AND MEASUREMENTS GIVEN BY FOWLER (1944) FOR *Cypselurus californicus* AND *"Parexocoetoides vanderbilti"*

	Cypselurus californicus	*Parexocoetoides vanderbilti*
Dorsal rays	I, 12	I, 10 or 11
Anal rays	I, 10 or 11	I, 9 to 11
Pectoral rays	I, 14	I, 13
Pelvic rays	6	6
Scales in axial series	64 to 70	65 to 70
Predorsal scales	47 to 48	45
Scales, dorsal origin to lateral line	8	11 to 12
Gill-rakers	8+13	5+14
Depth	6⅗ to 7	7 to 7¼
Head length	4 4/7 to 4⅔	4¾ to 4⅞
Head width	1⅘	1 9/10 to 2
Snout (in profile)	3⅛ to 4	4 to 4¼
Eye length	3⅕ to 3½	3 to 3⅖
Eye in interorbital	1⅕	1⅛ to 1⅕
Interorbital width	2⅓	2⅕ to 3

When the specimen was alive the barbels were conspicuous by reason of their red color as well as their bizarre form. In the freshly preserved specimen the bases of the fimbriae of the barbel were largely bright orange-pink. The parietal region was washed with orange-yellow. The bases of the pectorals and the back between them were faint yellow. There was a trace of yellow on the back between the pelvics.

What is obviously the same juvenile type was recently described by Fowler (1944: 420–422, 491, figs. 123–124) as a new genus and species, *Parexocoetoides vanderbilti*. This nominal species was based on four specimens, 208 to 220 mm. in total length, from off the west coast of Baja California at 27°40′ N. Lat., 116°50′ W. Long. As is indicated in Table II the counts and measurements given for these 4 specimens agree closely with those presented for 4 adults of *Cypselurus californicus* that were taken at the same place (Fowler, 1944: 419–420, fig. 115). The slight discrepancies in ray counts appear meaningless in the light of our counts for the species (Table I).

The stated differences in the number of scales in a transverse row and in the number of gill-rakers above the angle are presumably not significant, for in two adults of *C. californicus* we count 10 scales in a row extending from the dorsal origin downward and backward to but not including the lateral line, and in one adult the gill-rakers number 4 + 16 and 5 + 15 on the two sides. In the juvenile the body is a little slenderer and both head and snout are shorter—as would be expected. In our 69-mm. specimen the delicate body is still slenderer (depth, 7.7) and the head shorter (5.1). The snout measurement is 4.2 and the interorbital, 2.8.

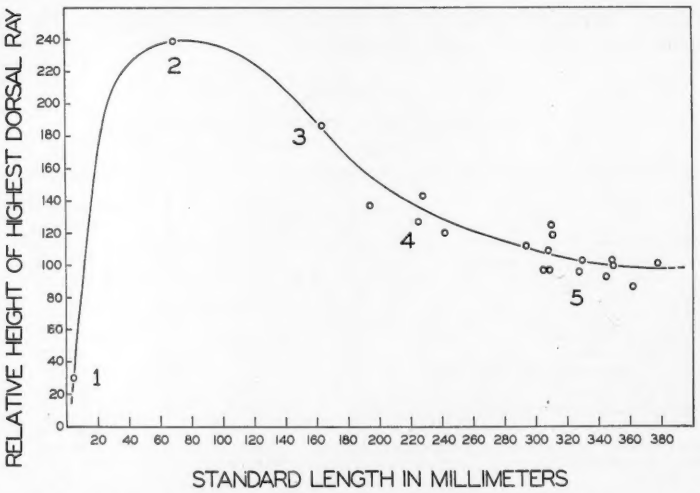


Fig. 4. Relative growth of dorsal fin of *Cypselurus californicus* in terms of length of longest ray expressed in thousandths of the standard length.

Point 1 represents the 4.5-mm. prolarva; point 2, the 69-mm. juvenile; point 3, the holotype of *Parexocoetoides vanderbilti* (plotted by calculation from type figure); points about 4, the half-grown; points about 5, the adults. Of the adults, the type of *C. californicus* is the smallest specimen.

The outstanding characters by which Fowler distinguished *Parexocoetoides vanderbilti* from *Cypselurus californicus* are the presence of a biblike barbel, the elevation of the dorsal fin and the blackening of the outer parts of the dorsal, pectoral and pelvic fins. These are the features which we regard as juvenile but which Fowler treated as diagnostic of his new genus and species.

Repeatedly the barbel has been thought to characterize the adult stage of some exocoetid, but eventually each barbelled fish has turned out to be the young of a nonbarbelled species. Furthermore, a decrease with age in the relative length of the barbel of *C. californicus* is indicated. As measured from the front of the gape, the length of the barbel in the type specimen of *P. vanderbilti*, which is 220 mm. in total length, is figured as only .074 of the standard length, whereas in the smaller specimen at hand the barbel length is .097 of the standard length.

The elevation and blackening of the dorsal fin in *"Parexocoetoides vanderbilti"* parallel the juvenile characteristics of several other synentognathous fishes. The change with age in these characters was particularly well described for *Tylosurus raphidoma* by Breder (1932: 17, pl. 4). Elevated and darkened dorsal fins appear from the later study by Breder (1938) to be generally though variably characteristic of juvenile exocoetids.

TABLE III

HEIGHT OF HIGHEST DORSAL RAY OF *Cypselurus californicus* AT VARIOUS SIZES

Specimen	Standard length, mm.	Height of highest dorsal ray[1]
Prolarva (near La Jolla)	4.5	3
Juvenile (off San Diego)	69	239
Juvenile (type of *P. vanderbilti*)	164[2]	186
Half-grown (27°30′N., 115°W.)	194	137
Half-grown (27°30′N., 115°W.)	225	127
Half-grown (27°30′N., 115°W.)	228	143
Half-grown (27°30′N., 115°W.)	242	120
Holotype (Catalina Island)	300	112
Adult (southern California)	305	97
Adult (southern California)	308	109
Adult (southern California)	309	97
Adult (southern California)	310	125
Adult (southern California)	311	109
Adult (27°30′N., 115°W.)	328	96
Adult (southern California)	330	103
Adult (southern California)	345	93
Adult (27°30′N., 115°W.)	349	103
Adult (southern California)	350	100
Adult (southern California)	362	87
Adult (southern California)	378	101

1 In thousandths of standard length.
2 Computed from measurements on type figure and from stated (total) length of 220 mm.

In *C. californicus* the relative height of the dorsal fin decreases rather regularly during the juvenile and half-grown stages (Table III). Thus in the 69-mm. juvenile the highest dorsal ray is .239 of the standard length; in the much larger type of *"P. vanderbilti,"* which probably represents about the extreme size of the barbelled juveniles, this proportion has dropped to .186; in half-grown of 194 to 242 mm. standard length, the relative length is .120 to .143; in the type of *C. californicus,* a subadult specimen 300 mm. long, the proportion is .112; in the adults, 305 to 378 mm. long, the figure varies from .093 to .125. When these data on the height of the dorsal fin are plotted (Fig. 4), with a point added to represent the height of the highest ray in the prolarva, the relative growth of the highest dorsal ray is seen to follow a peculiarly interesting curve. The dorsal fin must increase very rapidly in height in the younger juveniles, though the curve may not be quite as steep as is drawn in the figure. More material is needed to fix the form of the curve with precision. In the juvenile the fin becomes approximately two and one-half times as high as in the adult. The type specimen of *Parexocoetoides vanderbilti* (represented by point 3 on Fig. 4) is obviously transitional in dorsal fin height between the 69 mm. specimen (point 2) and the half-grown, and these in turn provide the gradation into the

subadult, represented by the type of *C. californicus* and thence into the adult.

The half-grown specimens at hand, mostly collected by George S. Myers on the 1938 Hancock Expedition, illustrate the gradation between *"Parexocoetoides vanderbilti"* and the adult of *C. californicus* in regard to coloration as well as to the height of the dorsal fin. A specimen of 194 mm. standard length, with the body form approximately matching that of Fowler's type specimen, has the dorsal fin largely black except near the base; the pelvic fin is almost wholly black except near the base and on the pale margin; within the narrow pale edge the pectoral is also mostly blackish, particularly on the outer half beyond a clear triangle that extends upward from near the middle of the lower border. In the half-grown about 225 mm. long the black on the fins has become definitely less intense and in other respects the coloration of the fins approaches that of the adult. In the adult the black of the dorsal is represented merely by a large sooty blotch and the paired fins are rather pale, becoming dusky within the pale borders.

The types of *Parexocoetoides vanderbilti* appear from the original figure to have lost the dark bars that are apparent on the ventral part of the body in the 69-mm. specimen.

There can be no doubt that the very peculiar juvenile shown on Figs. 1–3 is referable to *Parexocoetoides vanderbilti* and it is equally certain that *P. vanderbilti* represents the juvenile stage of *Cypselurus californicus*. Breder, who has had more experience than any other ichthyologist with juvenile flyingfishes, writes that he agrees with these conclusions. He points out that barbels and other juvenile features are long retained in several other species of Cypselurinae (as is indicated in his 1938 review). The retention of the barbel in young as long as 220 mm. in total length and the maintenance of the elevated blackened dorsal fin to an even larger size probably represent an extreme condition. It is in line with expectation, however, that the juvenile stage is retained unusually long in *Cypselurus californicus,* for this species is one of the very largest of the flyingfishes.

The Generic and Subgeneric Classification and the Relationships of *Cypselurus californicus*

Since *Parexocoetoides vanderbilti* Fowler is clearly a synonym of *Cypselurus californicus* (Cooper), the name *Parexocoetoides* becomes available for a subgenus or genus typified by the California flyingfish. This species may call for such distinction, for it fits very poorly into the generic analysis of the Cypselurinae proposed by Breder (1928: 14; 1938: 3) and Bruun (1935: 16). As defined by Bruun, the genera *Cypselurus* and *Prognichthys* are distinguished from *Danichthys* (the *Exonautes* of Breder, 1928) and from *Hirundichthys* by having the first ray of the anal on the same vertical as the fourth of the dorsal or behind this vertical, rather than below or in front of the third ray; further, in having the number of dorsal rays typically greater than and seldom equal to the number of anal rays, rather than equal or fewer. In these respects *C. californicus* is intermediate. In this species the first anal ray lies beneath the third to fifth dorsal ray, and the number of dorsal rays commonly equals the number of anal rays and averages less

than one ray higher. The intermediate position of *C. californicus* in the relative number of dorsal and anal rays may be statistically expressed (Table IV), by comparing our counts for *C. californicus* with the data presented by Bruun (1935) and by Breder (1938) for representative (Atlantic) species of the subfamily. Since the relative position of the fins likewise varies and grades from one extreme to the other, with *C. californicus* intermediate (compare data given above with Table 56 in Bruun's 1935 monograph), these fin characters would seem more pertinent to subgeneric than to generic distinction.

The difference in pectoral fin structure is much more consistent and more striking. With this point in mind we classify the Cypselurinae as follows:

Genus *Cypselurus* [16] Swainson (1839: 296, fig. 92)
Subgenus *Cypselurus* Swainson
Subgenus *Cheilopogon* Lowe (1841: 38)
Subgenus *Hirundichthys* Breder (1928: 14, 20)
Genus *Prognichthys* Breder (1928: 14, 20–21)
Subgenus *Prognichthys* Breder
Subgenus *Danichthys* Bruun (1934: 135)

The pectoral fin structure in *Cypselurus* seems to be primitive within the Exocoetidae, since in this respect *Cypselurus* agrees with the vast majority of flyingfishes as well as with all the Hemiramphidae, Belonidae and Scomberesocidae examined. The structure in *Prognichthys* is highly distinctive.

The characters of the genera and subgenera of Cypselurinae as here recognized may be summaried in key form:

ANALYSIS OF THE GENERA AND SUBGENERA OF CYPSELURINAE

1a.—First pectoral ray only unbranched; third ray longest. (Genus *Cypselurus*)
2a.—First anal ray below or behind fourth dorsal ray. Dorsal rays more numerous (usually 2 to 5 more) than the anal rays. Vertebrae 41 to 49 (typically fewer than 48; 49 as a rare variant). Barbel of juvenile simple, or double, never a broad fringed membrane; in some species very transitory and in some perhaps lacking. (Subgenus *Cypselurus*)
2b.—First anal ray below third to fifth dorsal ray. Dorsal rays usually only 1 or 2 more numerous than the anal rays, often of same number. Vertebrae 48 to 52. Barbel of juvenile a broad extensively fimbriate membrane. (Subgenus *Cheilopogon*)
2c.—First anal ray below or in front of third dorsal ray. Dorsal rays typically equaling or 1 fewer than anal rays. Vertebrae 44 to 47. Barbel of juvenile lacking. (Subgenus *Hirundichthys*)
1b.—Second as well as first pectoral ray unbranched; fourth ray or fourth and fifth rays longest. (Genus *Prognichthys*)
2d.—First anal ray below or behind fourth dorsal ray. Dorsal rays typically 3 more numerous than anal rays. Vertebrae 42 or 43. Barbel of juvenile lacking. (Subgenus *Prognichthys*)
2e.—First anal ray below or in front of third dorsal ray. Dorsal rays typically equaling or 1 fewer than anal rays. Vertebrae 45 or 46. Barbel of juvenile lacking. (Subgenus *Danichthys*)

[16] The original spelling was *Cypsilurus*, but it has been ruled by the International Commission on Zoological Nomenclature (Opinion 26) that "In view of the number of typographical errors in Swainson, 1838 and 1839, the Commission is of the opinion that *Cypsilurus* is an evident typographical error and should be corrected to *Cypselurus*."

TABLE IV

RELATIVE NUMBER OF DORSAL AND ANAL RAYS IN REPRESENTATIVE SPECIES OF CYPSELURINAE

Data for *Cypselurus californicus* are original; for *C. solandri* from Peters (1877: 555), Günther (1889: 36) and Bruun (1937: 186); for the other species, from Brunn (1935) and Breder (1938).

Genera, Subgenera and Species	Relative Number of Rays (D−A)											
	−2	−1	0	1	2	3	4	5	6	N	M	SE
Cypselurus (*Cypselurus*) *exsiliens*	..	..	..	..	..	2	11	8	5	26	4.62	0.18
Cypselurus (*Cypselurus*) *heterurus*[1]	..	..	..	..	..	8	23	10	1	42	4.10	0.11
Cypselurus (*Cypselurus*) *comatus*	..	..	..	..	..	6	11	2	..	19	3.79	0.17
Prognichthys (*Prognichthys*) *gibbifrons*	..	..	..	..	1	15	4	..	..	20	3.15	0.11
Cypselurus (*Cypselurus*) *furcatus*	..	..	..	..	9	11	4	4	..	28	3.11	0.19
Cypselurus (*Cypselurus*) *cyanopterus*	..	..	..	2	5	12	5	..	..	24	2.83	0.18
Cypselurus (*Cheilopogon*) *pinnatibarbatus*	..	..	2	10	8	5	1	..	..	26	1.73	0.20
Cypselurus (*Cheilopogon*) sp.	..	..	..	1	2	..	..	..	..	3	1.67	...
Cypselurus (*Cheilopogon*) *solandri*	..	..	..	3	..	..	..	..	..	3	1.0?	...
Cypselurus (*Cheilopogon*) *californicus*	..	2	26	64	22	1	..	..	..	115	0.95	0.07
Cypselurus (*Hirundichthys*) *affinis*	2	25	16	1	1	..	..	..	..	45	−0.58	0.11
Cypselurus (*Hirundichthys*) *speculiger*	2	22	17	1	..	..	..	..	..	42	−0.60	0.10
Prognichthys (*Danichthys*) *rondeletii*	2	12	9	..	..	..	..	..	..	23	−0.70	0.13

1 Including *C. lutkeni*, recognized as distinct by Bruun, but synonymized with *heterurus* by Breder.

Cypselurus californicus and the related species discussed below comprise the subgenus *Cheilopogon*.

Subgenus *Cheilopogon* Lowe

Cheilopogon.—Lowe, 1841: 38 (original diagnosis; monotype, *Cypselurus pulchellus* Lowe); 1842: 13–14 (identical material). Emended to *Chilopogon* in Agassiz's *Nomenclator Zoologicus*.

Ptenonotus.—Ogilby, 1907: 2, 13 (original diagnosis; orthotype, *Exocoetus cirriger* Peters). Breder and Nichols, 1930: 89 (distinct genus; species).

Parexocoetoides.—Fowler, 1944: 420–421 (original description; monotype, P. *vanderbilti* Fowler).

All three generic names cited above were based on juvenile flyingfishes with a wide fringed barbel around the mandible and a very high black dorsal fin. The respective type species are very much alike and there can be little doubt as to the naturalness of the group. It is thus apparent that *Parexocoetoides* represents a compact group which had already been named twice.

The pertinence of the name *Cheilopogon* to this group is virtually certain, because the monotype has the diagnostic juvenile characters, but the availability of the name may be debated. The only species mentioned by Lowe in the original account (published identically in 1841 and 1842), namely *Cypselurus pulchellus*, was described by him as having the dorsal fin "large, high, and produced." He wrote further that "the cirrate appendage to the lower jaw is like a leather flap or apron, torn irregularly at the bottom into strips or thongs." The queries as to availability arise from the fact that Lowe referred his species to *Cypselurus*, merely remarking, "I willingly abandon my own MS. name of *Cheilopogon* for this genus, distinguished from *Exocoetus* by the variously-appendaged lower jaw, in favour of the designation which I find this group of fishes has received from Mr. Swainson whilst this paper has been going through the press." Bruun (1935: 12) dismissed *Cheilopogon* with the remark that Lowe himself dropped this synonym of *Cypselurus*. It seems logical to conclude that Lowe abandoned his name *Cheilopogon* for reasons of validity and priority, rather than of availability. The name *Cheilopogon* was invalid only on the assumption that the respective type species of *Cheilopogon* and *Cypselurus* belonged to the same genus (or subgenus). Now that the genotypes appear to be referable to different subgenera, both names are regarded as available and are here adopted.

Like *Cheilopogon* the genus *Ptenonotus* was based on the same juvenile characters that were employed in the distinction of *Parexocoetoides*. The respective genotypes appear to be specifically distinct, but are so similar as to leave no grounds for subgeneric separation.

The subgenus *Cheilopogon* may be characterized as being intermediate between the subgenera *Cypselurus* and *Hirundichthys* in the number of rays in the dorsal and anal fins and in the relative positions of the origins of these two fins (pp. 203–204). The species of *Cheilopogon* appear to be extreme in the large size at which the juvenile transforms into the half-grown; in the very wide, highly fringed barbel; and in the very high, black dorsal fin of the juvenile. The character of the barbel as well as its presence or absence seems to have marked value in the taxonomy of the Cypselurinae (see key

to genera and subgenera). So far as known the barbel is a single or a double ribbon in the subgenus *Cypselurus* and appears to be usually if not always developed in that group. The barbel appears to be lacking in the subgenus *Hirundichthys* and in both subgenera of *Prognichthys*.

The dorsal fin characteristics are not exclusive to this group. Similarly the *Hemiramphus*-like body form typical of the juveniles of this group also characterizes other species. The sharpness of the projecting mandible is another feature in which the juveniles of *Cheilopogon* approach *Hemiramphus*—though not nearly so strikingly as does the young "*Hirundichthys* sp." that Giltay (1933: 45–46, fig. 16) described and figured.

Another character which may be used to define the subgenus *Cheilopogon* is the high number of vertebrae. In the Atlantic species, here called *Cypselurus* (*Cheilopogon*) *pinnatibarbatus*, the vertebrae number 50 to 52 (Günther, 1866: 287; Bruun, 1933: 379–380; Breder and Nichols, 1934: 42; Bruun, 1935: 50; Breder, 1938: 96–99). The only other species which is known to approach *pinnatibarbatus* in the vertebral number is *Cypselurus* (*Cheilopogon*) *californicus*, which has 48 to 51 vertebrae. Jordan and Evermann (1896: 740) attributed 49 vertebrae to this species. In 63 specimens from southern California dissected by us the average is 49.94 ± .08. The highest count reported for any species of the two other subgenera of *Cypselurus* here recognized is 44 to 49, in *Cypselurus* (*Cypselurus*) *heterurus* (Breder, 1938: 96).

Four species are referable to the subgenus *Cheilopogon*. They are listed below, with partial synonymy and a discussion of their status. The Hawaiian species which was described by Pietschmann (1928: 298; 1930: 8, pl. 2, fig. B) as *Ptenonotus melanogenion* obviously does not belong to this genus. It has been shown by Breder and Nichols (1930: 89) to be referable rather to *Parexocoetus*.

1. *Cypselurus* (*Cheilopogon*) *californicus* (Cooper)

Pl. I; Figs. 1–4

Exocoetus californicus.—Cooper, 1864: 93–94, fig. 20 (original description; type from Catalina Island; common south of Pt. Conception and wandering to Santa Cruz at least). Günther, 1866: 295 (description, after Cooper). Jordan and Gilbert, 1881*a*: 457 (Santa Barbara, San Pedro and San Diego, California); 1881*b*: 42–43 (flight; utility; ranging north to Pt. Conception; Santa Barbara Islands; Santa Catalina Island); 1883: 379 (description; about Santa Barbara Islands in summer). Jordan and Meek, 1885: 53, 64, 66–67 (comparison; full synonymy to date; remarks; range; off Santa Barbara and San Pedro in summer). Jordan, 1885: 371 (near Cape San Lucas). Eigenmann, 1892: 125, 129, 143 (synonymy; Pt. Loma and Cortes Banks in summer). Jordan and Evermann, 1896: 732, 740 (comparisons; description; synonymy; seasonal movements; Pt. Conception to Cape San Lucas).

Cypsilurus californicus.—Jordan and Evermann, 1898: 2836 (generic reference); 1900: 3258, pl. 119, fig. 319 (Santa Barbara). Jordan and Starks, 1907: 68, fig. 1 (figure of adult, not figure nor description of young). Fowler, 1944: 419–420, 491, fig. 115 (synonymy; description; off Lower California at 27°40′ N. Lat., 116°50′ W. Long; San Pedro and Catalina Island, California; Cape San Lucas).

Cypselurus californicus.—Starks and Morris, 1907: 183 (habits; San Pedro and Santa Barbara and Coronado islands). Metz, 1912: 31, fig. 4*a* (between Santa Catalina Island and mainland and near Laguna, California). Hubbs,

1918: 85–88 (flight). Breder and Nichols, 1934: 42 (number of vertebrae). Barnhart, 1936: 24, fig. 80 (description; Cape San Lucas to Pt. Conception). Nichols and Breder, 1936: 166 (off Baja California at 27° 31′ N. Lat., 114° 52′ W. Long. and at 30° 23′ N. Lat., 116° 19′ W. Long.). Edgerton and Breder, 1941: 311–314, pls. 1–8 (flight; Catalina Island).

Parexocoetoides vanderbilti.—Fowler, 1944: 421–422, 491, figs. 123–124 (original description; comparisons; off Baja California at 27° 40′ N. Lat., 116° 50′ W. Long.).

An examination of Cooper's original description and figure leaves no doubt as to the species that he treated. The holotype was unexpectedly located in the United States National Museum (No. 8140). Although the specimen was not designated as the type, circumstances make it virtually certain that it is. The original number (1012) and the size (about 15 inches over all), as well as the data (Catalina Island, J. C. Cooper), agree with the original account, which was based on a single example. The specimen is typical of *C. californicus* in form, color and small size of scales (nearly 50 between dorsal fin and occiput). The dorsal and anal rays number 11 and 10, respectively. The longest dorsal ray (pp. 200–201, Table IV, Fig. 4) is .112 of the standard length (just 300 mm.). The fact that the specimen is smaller than most adults taken in southern California confirms the interpretation that it is the holotype.

The limits of range of *Cypselurus californicus* remain to be accurately determined. According to Cooper it was common south of Pt. Conception but wanders northward at least to Santa Cruz. It is probable that he meant the town of Santa Cruz rather than Santa Cruz Island. If that be true, the species once ranged farther north along the coast than it now does. A number of other species of fishes also occurred farther north near the middle of the last century than they do at present (the evidence will be given in a forthcoming paper). The species is now common about all the Channel Islands off southern California and southward to off the southern part of the west coast of Baja California. Whether it ranges as far south as Cape San Lucas is not known with certainty. Jordan did record it from near Cape San Lucas but on what basis we do not know. The flyingfish reported by Steinbeck and Ricketts (1941: 47, 574, pl. 31, fig. 1) from between Magdalena Bay and Pt. Lazaro, Baja California, is obviously not *C. californicus*, as stated, and may well be the new species referred to earlier in this paper, for the body is too robust and the scales too large for *C. californicus*.

2. *Cypselurus* (*Cheilopogon*) species

Cypselurus californicus (misidentification).—Nichols and Murphy, 1922: 506 (length of fins; Central Chincha Island, Peru). Nichols and Breder, 1936: 166 (55 miles west of Masafuera Island, off Chile; Central Chincha Island, Peru).

Cypsilurus californicus.—Fowler, 1944: 491 (Central Chincha Island, Peru).

Danichthys rufipinnis (misidentification).—Hildebrand, 1946: 149–150 (reference to Peruvian record of *C. californicus*).

This species differs from *C. californicus* in having somewhat larger scales (40 to 41 in predorsal count) and the dorsal fin somewhat less posterior in origin (distance from dorsal origin to caudal base about 2.6 or 2.7 instead

of about 3.0 in predorsal length). It has been recognized as a distinct species by Myers and Wade, on the basis of one adult collected in the Galápagos Islands. A second specimen, obtained by the "Albatross" at Clarion Island off Mexico on March 4, 1889, was found in the United States National Museum (No. 46889). The specimen reported by Nichols and Breder from off Masafuera Island, in the Juan Fernandez group, proves on re-examination at the American Museum to be of the same species. It is inferred that the Central Chincha Island specimen is also conspecific, but it could not be found.

We regard this species as the tropical representative of *C. californicus*. Its pertinence to *Cheilopogon* requires the confirmation that might be provided by the discovery of the barbelled juvenile and by vertebral counts. It needs to be compared with *C. solandri* and with *C. pinnatibarbatus*.

3. *Cypselurus* (*Cheilopogon*) *solandri* (Valenciennes)

Exocoetus solandri.—Valenciennes, in Cuvier and Valenciennes, 1846: 129–131 (original description; type from "en mer á la hauteur des Séchelles," as fixed by Günther, 1889, but not the record from "pres d'Otahiti," which was based on a figure named *brachiopterus* by Solander, MS). Günther, 1889: 35–36, pl. 4, fig. A (description; East Africa; *E. solandri* of Günther, 1866: 285, regarded as distinct species). Bruun, 1937: 186 (redescription of type; probably identical with *E. cirriger;* referable without doubt to *Cypsilurus*).

Exocoetus cirriger.—Peters, 1877: 555–556, figs. 1–1*a* (original description; China). Ogilby, 1907: 2, 13 (type of *Ptenonotus;* known only from China Sea).

Ptenonotus cirriger.—Pietschmann, 1930: 8 (comparison).

Exonautes cirriger.—Chu, 1931: 88 (listed). Reeves, 1933: 224 (description compiled).

Cypselurus cirriger.—Fowler, 1932: 279, fig. 22 (after Peters).

Günther's figure of *Exocoetus solandri* from East Africa represents a juvenile *Cypselurus* which is scarcely distinguishable from the 69-mm. specimen at hand, even in finer details of form and coloration. There can be no doubt that it represents a species that is very closely related to *C. californicus*, perhaps even identical. It seems probable that Günther's specimen was conspecific with the the type of *E. solandri*. It is to be assumed, pending further study, that *E. solandri* is the same species that Peters later described and figured as *E. cirriger*. According to Peters this species has only 53 rows of scales. It therefore seems probable that the Indo-Pacific species *C. solandri* has larger scales than *C. californicus*, in which the rows number about 65 to 70. It will be noted that the scales are figured by Günther for *solandri* as being at least as small as they are in *californicus*, but he described the scales merely as "lost" and the artist may not have indicated the size accurately. Both Peters and Günther figured the barbel of the Indo-Pacific species as having the lateral borders more closely approximated, more even and less divided than in *californicus*. Peters' figure shows deeper incisions than Günther's. There is, however, no reliable basis for the recognition of more than one Indo-Pacific species of the subgenus *Cheilopogon* and further study is required to determine whether or how it is different from the Californian species, from the unidentified species of the eastern tropical Pacific, and from *Cypselurus pinnatibarbatus* of the Atlantic.

So far we have not been able to identify the adult of *C. solandri.* It would seem probable that the adult stage has already been named. The identification probably must await a critical study of the large cypselurine fauna of the Indo-Pacific. None of the species treated by Bleeker (1865: 105–129; 1866: 67–78, pls. 247–251) or by Weber and de Beaufort (1922: 179–194, fig. 63) seems to have the characters that one would expect to find in the adult of *C. solandri.*

4. *Cypselurus* (*Cheilopogon*) *pinnatibarbatus* (Bennett)

Exocoetus pinnatibarbatus.—Bennett, 1831: 146–147 (original description; Atlantic coast of northern Africa. Günther, 1866: 284 (description; Atlantic coast of northern Africa). Roule and Angel, 1921: 4 (Açores). Bruun, 1935: 52, 77 (possibly to be referred to *C. lineatus*).

Cypselurus pinnatibarbatus.—Fowler, 1936: 428 (references to Roule and Angel only).

Cypselurus pulchellus.—Lowe, 1841: 38 (original description; Madeira; monotype of *Cheilopogon*). Günther, 1866: 285 (cannot be separated from *C. solandri*). Bruun, 1935: 52, 77 (possibly to be referred to *C. lineatus*).

Exocoetus lineatus.—Valenciennes, in Cuvier and Valenciennes, 1846: 92–94 (original description; Atlantic Ocean at Gorée and the Canaries). Günther, 1866: 287 (description; Madeira). Jordan and Evermann, 1896: 739 (description, tropical Atlantic; Corea (*sic*), the Canaries; Madeira; Bermuda; synonymy).

Cypsilurus lineatus.—Jordan and Evermann, 1898: 2836 (generic reference). Bruun, 1935: 47–52, pl. 4, fig. 1 (description; synonymy).

Cypselurus lineatus.—Fowler, 1936: 429–431 (synonymy and records, except *E. spilurus* and *E. fucorum*). Breder, 1938: 49–50, fig. 24 (description; synonymy; Cape Verde Islands; Bermuda, record doubted).

Cypselurus minos.—Nichols and Breder, 1930: 1–2, 5, 8, fig. 2 (original description; Cape Verde Islands).

Exocoetus furcatus (misidentification).—Roule and Angel, 1930: 85, pl. 4, fig. 110 (description of juvenile; the Azores and "l'abri de Palma").

A species closely related to *Cypselurus californicus* and *Cypselurus solandri* occurs in the Atlantic. On the basis of the high number of vertebrae, the very large size, and the very late assumption of the fully adult coloration, all as pointed out by Bruun, it seems reasonably certain that this species is the one usually called *C. lineatus.* Juvenile flyingfishes resembling the young stages of *C. californicus* and *C. solandri* have been described three times from the Atlantic. Two of these descriptions are each the basis of a new name, antedating that of *Exocoetus lineatus.* The first of these names, *Exocoetus pinnatibarbatus* Bennett, was given to a 2-inch specimen with the outstanding characters of the *"Ptenonotus"* or *"Parexocoetoides"* juvenile stage: "dorsali altâ (depressâ caudalis medium attingente); cirro lato mentali profunde 15–20 radiatim secto." The second such name, *Cypselurus pulchellus,* was based on a young specimen having the dorsal fin "large, high, and produced" and "the cirrate appendage to the lower jaw is like a leather flap or apron torn irregularly at the bottom into strips or thongs." Neither of these descriptions was accompanied by a figure, but there can be little doubt as to the type of juvenile described. What is almost surely the same juvenile type was described and figured under the misidentification *Exocoetus furcatus* by Roule and Angel (1930: 85, pl. 4, fig. 110), on the basis of 3 specimens 52 to 56 mm. long. Concerning the barbel

they wrote: "Le barbillon mandibulaire subdivisé et rameux, est gros; sa longeur représente une fois et demie le diamètre orbitaire." The figure shows a very slender fish, much like the Pacific juveniles. The dorsal fin is shown as being blackish toward the tip of the lobe and as being greatly elevated, extending when depressed to above the middle of the median caudal rays. The pelvic is largely blackish and the pectoral has a submedian blackish band. The pigment on the body is chiefly confined to a submedian lengthwise stripe. From this description it is inferred that the Atlantic species differs somewhat from *C. californicus* in the coloration of the juvenile.

Exocoetus fucorum Zugmayer (1911: 60–61, pl. 2, fig. 6) was listed by Bruun (1935: 52) among the juvenile stages possibly to be referred to *C. lineatus,* and was favored by Breder (1938: 49) as the young of *C. lineatus* and was definitely so identified by Fowler (1936: 430–431). It seems almost certain, however, that *E. fucorum* was not based on a species of *Cheilopogon.* It was described as having a pair of barbels which are lost before the fish attains a length of 20 mm. Furthermore, Zugmayer counted 4 more dorsal than anal rays in *E. fucorum,* whereas only one specimen of the present species out of 26 counted shows that large a difference (Table IV).

In view of the developmental changes which we demonstrate to take place in *Cypselurus californicus,* it seems reasonable to conclude that *Exocoetus pinnatibarbatus* Bennett and *Cypselurus pulchellus* Lowe were based on the species that was later described as *Exocoetus lineatus.* We therefore adopt the oldest of these names as the designation of the species. Bruun (1935: 51–52) considered it as probable that *Exocaetus Commersonnii* Lacépède (1802: 158–168; 1803: 402–409) was also based on the same species. In our opinion, however, this conclusion is improbable, for the descriptions of *commersonnii* appear to be inadequate for identification.

Fowler (1936: 427–429, fig. 214) uncritically referred *C. pulchellus* to the synonymy of *C. furcatus* and used the name *C. pinnatibarbatus* for another species.

Summary

Various developmental stages of an exocoetid fish from southern California have been described and figured. They have been identified as *Cypselurus californicus* (Cooper) on the assumption that they must represent the only species of common occurrence in California. It now becomes apparent, on the basis of highly distinctive egg and juvenile characters, that these young stages belong to another species of *Cypselurus.* The large egg of that species has the adhesive filaments restricted to opposite polar patches whereas the smaller ovum of *C. californicus* has the threads rather evenly attached over the entire surface. These differences exemplify the wide variety of egg size and structure that is exhibited by the synentognathous fishes (see key on pp. 191–93). The egg characters may well have phylogenetic import and are paralleled by distinctions within the Atherinidae. Differentiation between the two Californian species are also apparent in the larval and juvenile stages and such distinctions will probably be found to hold generally throughout the Exocoetidae.

A greatly elevated, blackened dorsal fin and an immense, fimbriated bib-

like barbel, a *Hemiramphus*-like body form, and other characters are now found to characterize the young of *C. californicus*. These juvenile features, along with the high number of vertebrae and the relative position and ray number of the dorsal and anal fins, distinguish this flyingfish trenchantly from most other species of *Cypselurus*. In all these respects, however, *C. californicus* is closely matched by *C. solandri* (*C. cirriger*) of the Indo-Pacific fauna and by *C. pinnatibarbatus* (*C. lineatus*) of the Atlantic. These three species, and another, unnamed, may be regarded as constituting a distinct subgenus *Cheilopogon* Lowe, 1841, with two synonyms: *Ptenonotus* Ogilby, 1907, and *Parexocoetoides* Fowler, 1944. *Parexocoetoides vanderbilti* was certainly based on the bizarre juvenile phase of *Cypselurus* (*Cheilopogon*) *californicus*.

Cheilopogon is intermediate between *Cypselurus* and *Hirundichthys* in the relative position and the ray number of the dorsal and anal fins—the assigned distinctions between those nominal genera. Because in each respect there is an extensive gradation from one extreme to the other, the three groups are treated as subgenera. *Prognichthys* and *Danichthys*, which have been generically separated on the same flimsy basis, are likewise regarded as only subgenerically distinct. *Cypselurus* and *Prognichthys*, however, are considered to be generically separable on the basis of the very different structure of the pectoral fins. Within the Cypselurinae (see key on p. 203) the structure of the barbel as well as its presence or absence appears to be of taxonomic significance.

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SCRIPPS INSTITUTION OF OCEANOGRAPHY, LA JOLLA, CALIFORNIA.

Thoburnia hamiltoni, a New Sucker from the Upper Roanoke River System in Virginia

By EDWARD C. RANEY[1] and ERNEST A. LACHNER

IN the spring of 1941, during the course of our ichthyological explorations in Virginia, we captured 5 specimens of a catostomid fish which represents a second species of the little known genus *Thoburnia*. It was first tentatively identified as *Thoburnia rhothoeca* (Thoburn), and on this basis Hubbs and Raney (1944: 16) erroneously added the Roanoke system to the range of *T. rhothoeca*. However, re-examination proves it to be a new species. Two other series of 4 specimens each in the U. S. National Museum have been examined through the kindness of Dr. Leonard P. Schultz, Curator of Fishes.

Fowler (1945: 24, 75) also records *Thoburnia rhothoeca* from the Roanoke river system either on the basis of the Hubbs and Raney record mentioned above, or on the assumption that Jordan (1890: 121, 122) had both *Moxostoma cervinum* and *Thoburnia rhothoeca* from Black Creek, Salem and Roanoke (Roanoke drainage), Virginia. It is clear that on the basis of Jordan's (1890: 109) remarks, the specimens from Buffalo and Elk creeks, James River system, which he records as *Moxostoma cervinum*, were largely *Thoburnia*. However, no statements were made by Jordan on the coloration of *Moxostoma cervinum* taken in the Roanoke River system and we believe there is no reason for assuming he had both species.

Superficially the two species, *Moxostoma cervinum* and *Thoburnia rhothoeca*, look somewhat similar since both are small fishes with dark

[1] The field studies during which this new sucker was collected were supported by a grant from the Faculty Research Fund of Cornell University.

saddles across the back. Indeed, in the original description of *M. cervinum* Cope (1869: 236) confused both species and listed *M. cervinum* from both the James and Roanoke rivers, Virginia. A year later Cope (1870: 479) persisted in this error, as has been pointed out by Hubbs (1930: 43) in his critical summary which gives the early history of *Thoburnia* in some detail. In the following key we outline the major differences between *Thoburnia* (both species) and *Moxostoma cervinum*. Obviously it includes both specific and generic characters, some of which, like the black peritoneum and the large number of radii on the scales of *Thoburnia*, have not hitherto been pointed out.

1a. Air bladder of three chambers and well developed in adult. Posterior fontanelle wide. Peritoneum silvery. Scales with relatively few light radii concentrated on the anterior and posterior fields and with few or none on the lateral field. Mouth small and less inferior, a line perpendicular from the posterior border of lower lips not reaching behind nostril in adults. Lips plicate; halves of lower lips meeting posteriorly in an obtuse angle. Pronounced black edge to anterior lobe of dorsal fin and posterior edge of caudal lobes. Dorsal rays mostly 11, occasionally 10. Lateral line scales larger, usually 40 to 42. Many prominent light longitudinal streaks running the length of the sides and back. Range; Roanoke River system, Virginia and south..... *Moxostoma cervinum*

1b. Air bladder of two chambers, tending to be reduced in the adult.[2] Posterior fontanelle obliterated. Peritoneum black. Scales with many coarse radii on all fields. Mouth larger and more inferior, the posterior border of lower lips reaching nostril in adults. Lips plicato-papillose; lower lips truncate behind. No black on edge of dorsal and caudal fins. Dorsal rays 10, occasionally 11. Lateral line scales smaller, 43 to 51 (mean 46). Light longitudinal streaks on the body best developed along the sides. Range; both Roanoke and James River systems, in Virginia and West Virginia..... *Thoburnia*

Thoburnia ***hamiltoni,*** new species

Roanoke Rustyside Sucker

Plate 1, Map 1

RANGE (Map 1).—The three collections of this species are all from tributaries of the Dan River system, a southern tributary of the Roanoke River, in southern Virginia. Despite the paucity of specimens at hand, it is probably common in the mountain streams of this limited area. Considerable collecting in other parts of the Roanoke system, especially in the vicinity of Roanoke, has failed to yield this species. The only other species in this genus, *Thoburnia rhothoeca*, is common throughout the upper James River system in Virginia and West Virginia. Hubbs and Raney (1944: 12) reported *rhothoeca* from the upper Kanawha system in West Virginia on the basis of a specimen in the Cornell University Collection, No. 4957,

[2] In 3 adult *Thoburnia rhothoeca*, 86, 92, and 120 mm. in standard length, the posterior chamber of the air bladder (the longest chamber) measures 7.5, 6.5, and 9 mm. respectively. Dobbin (1941: 4, 27, fig. 6) gives additional data and figures the air bladder.

supposedly taken in Second Creek at its mouth, Greenbrier River, Greenbrier County, West Virginia, by Dr. A. H. Wright. We doubted this locality thinking perhaps the fishes had been mixed by students, since, after collecting near this same area, we failed to find it. However, there are 3 specimens in the U. S. National Museum, No. 39529, collected by Col. Marshall McDonald in the summer of 1885 (?) from Wolf Creek, a tributary of the New River, Giles County, Virginia, which confirms its presence in the Kanawha system. McDonald also collected 12 specimens, U.S.N.M. 131125, at Waynesboro, and 1 specimen, U.S.N.M. 132071, was collected in War Branch, a tributary of Dry River near Rawley Springs, Shenandoah River drainage, Rockingham County, Virginia, in the summer of 1885. If these data are correct on the collections, another drainage system, the Potomac River system, is added to its range. Thoburn, in the original description of *rhothoeca* in Jordan and Everman (1896: 182), lists 6 specimens as types and the type locality as "at some point in eastern Tennessee or southwestern Virginia, thought to be from French Broad River at Wolf Creek, Tennessee." Since exhaustive seining by T.V.A. biologists has failed to reveal specimens of *rhothoeca* in the Tennessee River system, we follow Hubbs (1930: 44) in assuming that the types were taken somewhere in Virginia, probably in the James River system. We have examined 2 types of *rhothoeca* in the U. S. National Museum, No. 44846, and 1 of the 4 types in the Stanford University Natural History Museum, No. 1030, kindly loaned by Dr. George S. Meyers, Curator of Zoological Collections. These 3 specimens are typical of *Thoburnia rhothoeca*, which is now known only from the James, Upper Kanawha, and Potomac systems.

It is to be regarded as a relict species. The ancestral stock of *Thoburnia hamiltoni* may have reached the upper tributaries of the Dan River from the New River system by stream capture. This possibility is enhanced since it is a species of headwater mountain streams. However, if it came from the New River system it must be assumed that in the past *Thoburnia* was more abundant than recent collecting has shown it to be since no specimens have been taken since about 1885. Several other species and subspecies, namely *Schilbeodes gilberti* (Jordan and Evermann), *Percina rex* (Jordan and Evermann), *Boleosoma podostemone* (Jordan and Jenkins), and *Ambloplites cavifrons* Cope, have been found only in the Roanoke River system.

MATERIAL.—The holotype, 87 mm. in standard length, was collected together with 4 paratypes, all males 85 to 97 mm. in standard length, on

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PLATE I[1]

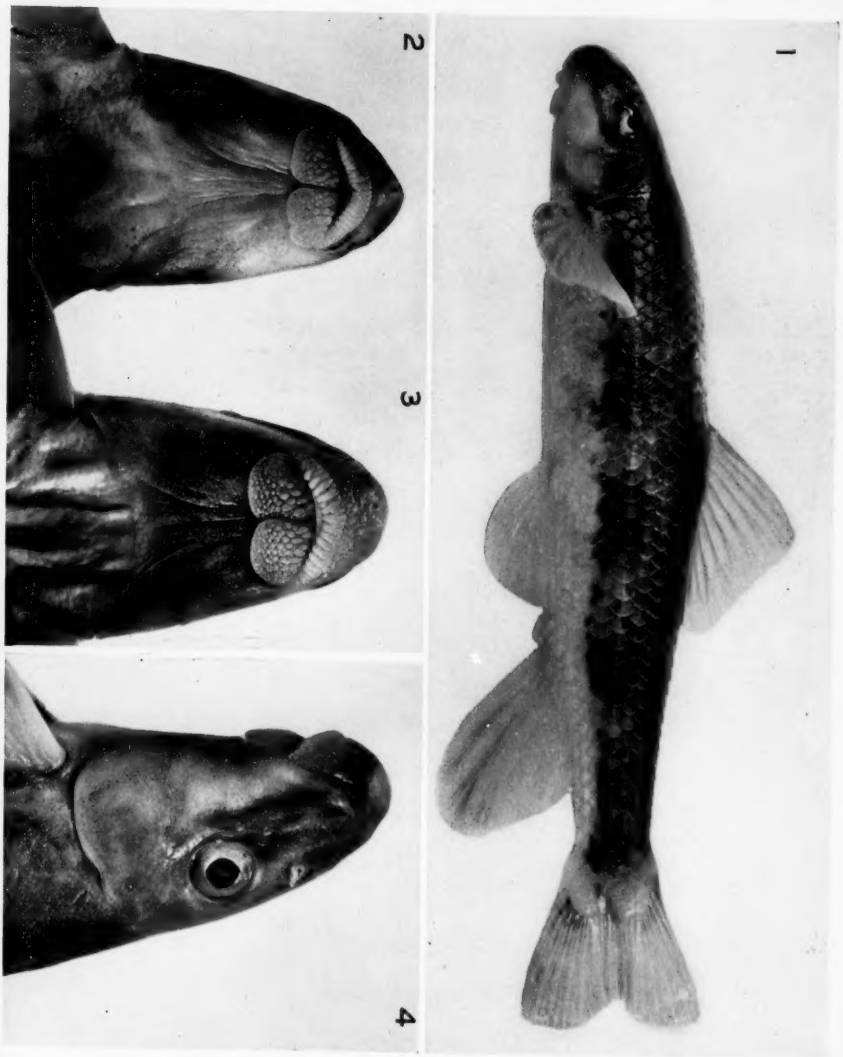
Thoburnia hamiltoni, new species

1. Holotype, 87 mm. in standard length, collected by Edward C. Raney, Ernest A. Lachner, and Roman A. Pfeiffer, on April 3, 1941, in Anglin Creek, Roanoke River system, 1 mile west of Patrick Springs, Patrick County, Virginia.

2. Ventral view of the head of a male *Thoburnia rhothoeca*, 98 mm. in standard length, collected on April 7, 1940, in Tye River, James River system, 2 miles northwest of Roseland, Nelson County, Virginia.

3. Ventral and (4) lateral views of the head of a paratype, a male, 97 mm. in standard length, from the same locality as the holotype.

[1] Photographed by Art Smith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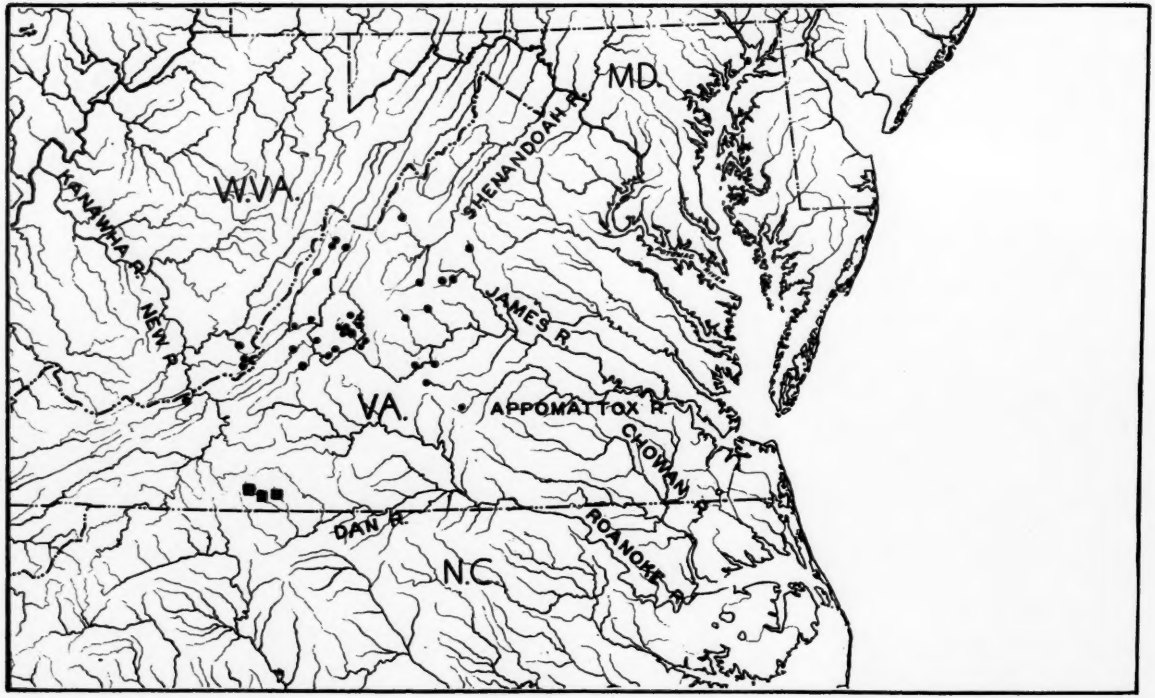

MAP 1

Distribution of *Thoburnia hamiltoni* and *Thoburnia rhothoeca*, as indicated by record stations. Black squares represent the localities of *Thoburnia hamiltoni* examined. The middle square marks the type locality. Black circles represent *Thoburnia rhothoeca*. Specimens were examined from each of the localities.

April 3, 1941, by Edward C. Raney, Ernest A. Lachner, and Roman A. Pfeiffer, in Anglin Creek, 1 mile west of Patrick Springs, 3.5 miles east of Stuart, on U. S. route 58, Patrick County, Virginia. The holotype, No. 146498, and 1 paratype, No. 146499, have been deposited in the Museum of Zoology, University of Michigan, and the remaining 3 are in the Cornell University Collection, No. 9559.

Four paratypes, 65 to 97 mm. standard length, were collected by Leonard P. Schultz and Earl D. Reid, July 13, 1938, in Mayo River, 1 mile above Stuart, Patrick County, Virginia: U.S.N.M. 107546. Four additional paratypes, 59 to 105 mm., were taken by Schultz and Reid on June 13, 1937, in Spoon Creek between Martinsville and Stuart, Patrick County, Virginia; U.S.N.M. 104098.

DESCRIPTION.—This species differs trenchantly from *T. rhothoeca* in the larger and more inferior mouth, rounded head, and the character and size of the lower lobes of the lips. The outstanding differences are noted in the key below. Additional meristic characters of the two species are given in Tables I and II.

KEY TO THE SPECIES OF *Thoburnia*

1a. Head rounded; mouth larger and more inferior. Entire lower lip tending to be papillose but outstandingly so on the posterior two-thirds; the papillae on the posterior half of the lip are almost circular. Lower lip much more fleshy and longer so that a vertical from the posterior edge of lip passes through the eye. Lower lip more truncate and the two halves meet medially in a shallow notch. Upper lip: the plicae are less regularly arranged and there is a slight tendency for the plicae to break up into papillae. Gape wider; greatest width of lips (outside measurement) into postocular head one or more times. Small regularly placed chromatophores present on the snout just above the upper lip. Pectoral fins with much more pigment on anterior half. Faint light longitudinal streaks on dorsum (except occasionally on the midline) in front of the dorsal fin, also present on sides of body. Scales of the anterior dorsum are less densely pigmented on the center of the posterior field of each scale. Eye smaller. Range: Roanoke River system, Virginia..... *Thoburnia hamiltoni*

1b. Head bluntly pointed (especially when viewed from above and laterally), mouth smaller and less inferior. Anterior half of lower lip plicate, with plicae breaking up posteriorly into oblong ridges, somewhat papillose near extreme posterior border. Lower lip less fleshy and a vertical from posterior edge of lip passes in front of eye. Lower lip less truncate and quite deeply notched where the halves of the lower lips meet medially. Upper lip: plicae quite regularly arranged and little tendency to break up. Gape narrower; greatest width of the lips into postocular head less than one time. Pigment lacking on snout just above upper lip; this area is light without small regular black chromatophores. Less pigment on anterior half of pectoral fin. Light longitudinal streaks usually limited to sides and not visible on dorsum in front of dorsal fins (except in some very old bleached specimens). Scales of the anterior dorsum are rather uniformly densely pigmented. Eye larger. Range: James, upper Kanawha, and Potomac River systems..... *Thoburnia rhothoeca*

Specimens were examined from each of the localities

Many of the characters are portrayed by the figures (Plate I) and the data in Tables I and II. Additional items based on the holotype and 12 paratypes follow. Unless otherwise specifically mentioned, counts and measurements were taken in a manner described by Hubbs and Lagler (1941: 12–20). Fin and scale counts of the holotype are: dorsal rays 10; anal rays 7; pelvic rays 9–9; pectoral rays 16–16; caudal rays 18; lateral line scales 43; scales above lateral line to origin of dorsal 6; scales below lateral line to origin of anal fin 7; scale rows around narrowest part of caudal peduncle 17. Corresponding counts for the 12 paratypes are: dorsal rays 10 in 11 specimens and 11 in 1; anal rays 7 in all but 1 which had 6; pelvic rays 9–9; pectoral rays 16–16 in 5, 15–16 or 16–15 in 3 and 15–15 in 4; caudal rays 18; lateral line scales are given in Table I; scales above lateral line, 5 in 1 specimen, 6 in 8 and 7 in 3; scales below lateral line, 6 in 8 and 7 in 4; scales around caudal peduncle, 16 in 6, 17 in 4, and 18 in 2.

TABLE I

LATERAL LINE SCALE COUNTS OF *Thoburnia*

	Number of lateral line scales										
	43	44	45	46	47	48	49	50	51	No. spec.	Mean
Thoburnia hamiltoni Holotype and paratypes from Roanoke River system, Virginia	1	1	4	3	4	..	..	..	..	13	45.6
Thoburnia rhothoeca From various localities in Virginia and West Virginia											
Appomattox River system, Va.	2	..	4	3	..	..	..	..	..	9	44.9
Tye River, Nelson Co., Va.	..	1	4	7	9	7	2	..	..	30	46.8
Lickenhole Creek at Mechum, Albermarle Co., Va.	..	2	7	7	2	3	2	..	..	23	46.1
Waynesboro, Augusta Co., Va.	2	1	2	2	3	..	..	..	..	10	45.3
Catawba Cr., Botetourt Co., Va.	..	..	3	11	6	3	1	2	..	26	46.6
Wilson's Creek near Clifton Forge, Alleghany Co., Va.	..	6	7	5	2	..	..	..	..	20	45.2
Pounding Mill Creek, Alleghany Co., Va.	..	2	3	7	9	..	1	..	..	22	46.2
Jackson River at Vanderpool, Highland Co., Va.	1	..	5	5	9	2	1	..	1	24	46.5
Potts Creek, Monroe Co., W. Va.	..	1	4	4	5	7	1	1	1	24	47.0
Total includes 13 small collections not given above	6	15	43	65	57	22	10	3	2	223	46.3

Like *Thoburnia rhothoeca*, *hamiltoni* is well adapted structurally for life in swift mountain streams. The body is subterete; the ventral contour

is straight in front, slopes upward along the base of the anal fin, but is again straight along the underside of the caudal penducle. The snout is rounded, the head small and slightly convex between the eyes. The dorsal contour is curved and gradually reaches the greatest body depth at or just anterior to the origin of the dorsal fin. Just posterior to the dorsal origin the contour curves downward but straightens out in the region dorsad of the origin of the anal fin and parallels the ventral border of the caudal peduncle. The dorsum behind the dorsal fin is rounded. In front of the dorsal there is a slight ridge which extends forward nearly to the occiput. The widest part of the body is just anterior to the dorsal fin and, posteriorly, the lateral contour is almost straight or but slightly curved to the base of the caudal fin.

TABLE II

PROPORTIONAL MEASUREMENTS OF *Thoburnia*

Minimum, maximum and average values are given for specimens other than holotype.

Species	*Thoburnia hamiltoni*		*Thoburnia rhothoeca*
River system	Roanoke		James
Specimens	Holotype	12 paratypes	14 specimens
Standard length in mm.	87	59–105	63–116
In standard length			
Predorsal length	2.05	2.05–2.1 (2.08)	2.05–2.1 (2.08)
Dorsal origin to occiput	3.4	3.2 –3.6 (3.4)	3.2 –3.6 (3.4)
Body depth	4.6	4.7 –5.2 (4.8)	4.3 –5.0 (4.6)
Body width	5.4	5.6 –6.2 (5.9)	5.3 –6.0 (5.5)
Caudal peduncle length	5.7	5.3 –6.1 (5.7)	5.4 –6.2 (5.8)
Head length	4.6	4.4 –4.7 (4.6)	4.3 –4.7 (4.55)
Anal fin length[1]	3.8	3.7 –4.7 (4.1)	3.7 –4.4 (4.0)
Dorsal fin ♂	3.8	3.65–3.9 (3.8)	3.4 –3.9 (3.6)
Dorsal fin ♀	...	4.1 –4.3 (4.2)	4.1 –4.3 (4.2)
In head			
Snout length	2.0	1.9 –2.3 (2.05)	2.0 –2.2 (2.1)
Bony interorbital	2.7	2.3 –2.7 (2.5)	2.5 –2.8 (2.7)
Lower lip outside width	2.2	2.2 –2.4 (2.3)	2.4 –2.8 (2.6)
Pectoral fin	0.9	0.9 –1.0 (0.94)	0.8 –1.0 (0.9)
Pelvic fin	1.1	1.1 –1.2 (1.16)	1.1 –1.3 (1.2)
Dorsal origin to lateral line	1.7	1.7 –2.0 (1.8)	1.5 –1.9 (1.7)
Pelvic origin to lateral line	2.0	1.9 –2.2 (2.1)	1.8 –2.3 (2.0)
Snout tip to posterior border of lower lips	2.05	2.0 –2.2 (2.1)	2.2 –2.7 (2.4)
Caudal peduncle depth	2.2	2.05–2.5 (2.25)	2.05–2.5 (2.2)
Head depth at occiput	1.5	1.4 –1.75 (1.5)	1.4 –1.5 (1.44)
In snout			
Eye	2.4	1.9 –2.6 (2.3)	2.0 –2.7 (2.2)

1 All fin lengths measured from the origin to the posterior tip of the longest or last ray, whichever distance was greater.

The head is deepest at the occiput. The eye is dorsally situated, being somewhat supralateral, and is nearer the opercular margin than tip of snout. Laterally the snout is quite rounded, with considerable adipose tissue which gives it a much different appearance than the sharper snouted *T. rhothoeca*.

The small air bladder is of two parts. The posterior bladder, which is by far the longer portion, measured 5.5 mm. in the largest adult paratype, 105 mm. in standard length.

The free edge of the dorsal fin is slightly concave. The male has a longer dorsal; the distance from the origin to the end of the posteriormost ray goes into the standard length 3.8 times; in females it averages 4.2. The pectoral fins are broad and rounded and much less pointed than in most *rhothoeca*. The ventral and anal fins are rounded, with third and fourth rays longest. The lobes of the caudal fin are subequal, the ventral lobe being slightly longer.

The mouth is inferior, with a long fleshy lower lip which reaches far back so that a vertical through its most posterior margin touches the eye. It tends to be papillose, especially on the posterior two-thirds. The papillae on the last half are approximately circular. There is only a slight notch where the halves of the lower lips meet. The upper lip has irregular plicae which tend to break up into papillae. The gape is wide. The greatest outside width of the lips equals or is greater than the postocular part of the head (less in *T. rhothoeca*).

The body is rather sharply bicolored, the dorsum is dark olive to brownish, crossed by four fairly well developed blackish saddles. These saddles are located just in front of and about the base of the first several rays of the dorsal fin, just posterior to the dorsal fin, immediately dorsad of the anal fin, and at the base of the procurrent rays of the caudal fin. They extend ventrally to within two scale rows of the lateral line. Along the side are five quite irregular black, roughly quadrate shaped patches which tend to alternate with the black saddles on the posterior half of the fish. The type series of ripe males from Anglin Creek had a red lateral band in life. These patches give the impression of an interrupted dark lateral band about three scale rows in width. However, this band is not nearly as pronounced as the rather sharp one found in *Thoburnia rhothoeca* from Potts and Cove creeks, Monroe County, West Virginia. The dark ground color of the upper part of the body is lined longitudinally with alternating dark and light streaks except sometimes on the middorsal region anterior to the dorsal origin. These streaks are most prominent along the sides and there are two very light bands just above the lateral line running from opercle to base of tail. They are due to a lack of dark pigment on the center of the posterior field of the scale. This streaking is less pronounced along the side in *T. rhothoeca* but reaches almost perfect development in *Moxostoma cervinum* and *M. rupiscartes*. One scale row below the lateral line the body is of contrasting white color. However, there is some scattered dark pigment, concentrated mostly anteriorly between the pectoral and pelvic fins, which reaches as far ventrad as the origin of the pelvic fin. On top of the head and most of snout are rather coarse dark markings which tend to form a semi-reticulate pattern in front of the eyes. The top of the head is uniformly dark except for occasional blacker markings and a semi-oval light spot about equal in area to the eye, situated just behind and mesad to the eye where the supraorbital branch of the lateral line system branches off. These high spots are not as well developed in the related *rhothoeca*. The lips are unpigmented but the center of the snout immediately above the upper lip

is covered with small evenly spaced black dots which are scarce or absent in *rhothoeca*. The upper cheek is dark and contrasts with the light lower cheek and underside of the head. There are a few scattered dark pigment flecks on the lower cheek. The opercle is dark above, grading into light below, and the dark pigment reaches more ventrad than on the cheek.

The pectoral fin is dusky, especially on the anterior half. The pigment tends to be concentrated just laterad of the rays. The small dark pigment flecks are sparse on the other fins and are also concentrated laterad of the rays rather than on the fin membranes. The lateral aspect of the posterior caudal peduncle is mostly covered by a dark blotch. In contrast, the area just anterior of the fin is quite white, especially above and below the midline, and forms two lunar-shaped light spots. These spots again contrast to the irregular dusky pigment at the base of the caudal fin. On this fin, as in the others, the dark pigment is concentrated along the rays. It is more dense near the base of the fin.

The pharyngeal arch (in an adult paratype) is curved as in other catostomid fishes, but the arch is weak in structure, the base being scarcely higher than wide. The teeth are comb-like with a total of about 30 on each side. Each tooth is thin, somewhat wider at the base than at the tip and about three times as long as wide. The basal portion of each tooth narrows outward, until about one-third of the distance from the arch, after which the edges of the tooth are approximately parallel. The distal edge of each tooth is notched and with a sharp tooth-like extension on the inner edge, especially in the teeth on the outer two-thirds of the arch. The teeth near the base of the arch have the tooth more rounded on the cutting edge although they are still noticeably notched.

The gill rakers (in an adult paratype) number 22 in the anterior series and 27 in the posterior. In shape each raker is like a right triangle with many small fleshy extensions on the hypotenuse side. The longest gill rakers are about four times the length of the longest gill filaments. The pharyngeal arch, teeth, and gill rakers are similar to those of *T. rhothoeca* in shape and number.

A description of the breeding tubercles as they occur on the holotype and 4 paratypes from Anglin Creek follows. The pearl organs are best developed on the center of the anal fin. Just laterad to each ray there is a single line of 5 to 10 strong tubercles, consisting of a rounded base with a sharp nipple on top. Small tubercles line each ray of the caudal fin. Those on the lower half of the fin are best developed. Relatively few fine tubercles are scattered over both surfaces of the pectoral and pelvic fins. None were observed on the dorsal fin. The posterior edge of almost every scale on the posterior half of the body is lined with small pearl organs. They are best developed on the lateral and underside of the caudal peduncle. There are a few scattered tubercles on the anterior half of the body and on the head.

The anal papilla of the breeding male is a short tube with a small inflated pouch on the ventral side. This pouch is about as wide as long and has several longitudinal ridges.

HABITAT.—The type locality is a small mountain stream, 2 to 10 feet wide and quite shallow, with depths of up to 3 feet in the pools. The water

was white and clear, the current moderate to swift, and the flow was estimated at approximately 5 cubic feet per second. No vegetation was present and the bottom was rubble and large gravel. The 5 males were captured in the riffles and were ripe; upon slight pressure the milt ran freely. The air temperature was 60°, the water 56° F. at 4 P.M. Many individuals of rather few species were also taken at this locality. They were *Hypentelium nigricans, Semotilus atromaculatus atromaculatus, Nocomis leptocephalus, Chrosomus oreas, Clinostomus vandoisulus, Notropis cerasinus, Schilbeodes marginatus atrorus,* and *Catonotus flabellaris. Notropis cerasinus, Chrosomus oreas* and *Clinostomus vandoisulus* were common to abundant. One specimen of a hybrid, *Chrosomus oreas* x *Notropis cerasinus,* was captured. Dr. Leonard P. Schultz informs us that the paratypes from Mayo River came from swift flowing water among stones and rubble, and he also took many of the same associated species plus *Catostomus c. commersonnii.*

This sucker is named for our friend and teacher, Dr. William J. Hamilton, Jr., vertebrate zoologist of Cornell University, whose stimulating suggestions and assistance over a period of ten years have been invaluable.

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Notes on the Arctic Grayling, *Thymallus signifer* Richardson, from Great Bear Lake[1]

By Richard B. Miller

IN the summer of 1944 the Fisheries Research Board of Canada began a series of studies of the waters of the Northwest Territories to discover what fishery resources they contained. As a part of this program the author took a small party to Great Bear Lake during the summer of 1945. Great Bear Lake lies 60 miles east of the MacKenzie River and about 400 miles north of the Alberta boundary; its northern tip is intersected by the Arctic circle. It is the fourth largest North American lake, with an area of 11,800 square miles. It is enormously deep; we found depths of over 1,300 feet and most of the lake is 400 feet or more deep. The water is frozen or at freezing temperature from September to June; the brief summer allows the surface water of the open lake to warm to a maximum of 50–54°F.

This great, inhospitable lake is the home of the Arctic grayling, from whence it was described in 1836 by Richardson (*Salmo signifer*). Because of the general nature of our survey, the enormous area involved, and the brevity of the season, our collections of this fish were small and our observations somewhat meager. We feel, however, that opportunity to collect this species from the type locality may not easily or soon come again, and that our data, though fewer than desirable, are worthy of going on record.

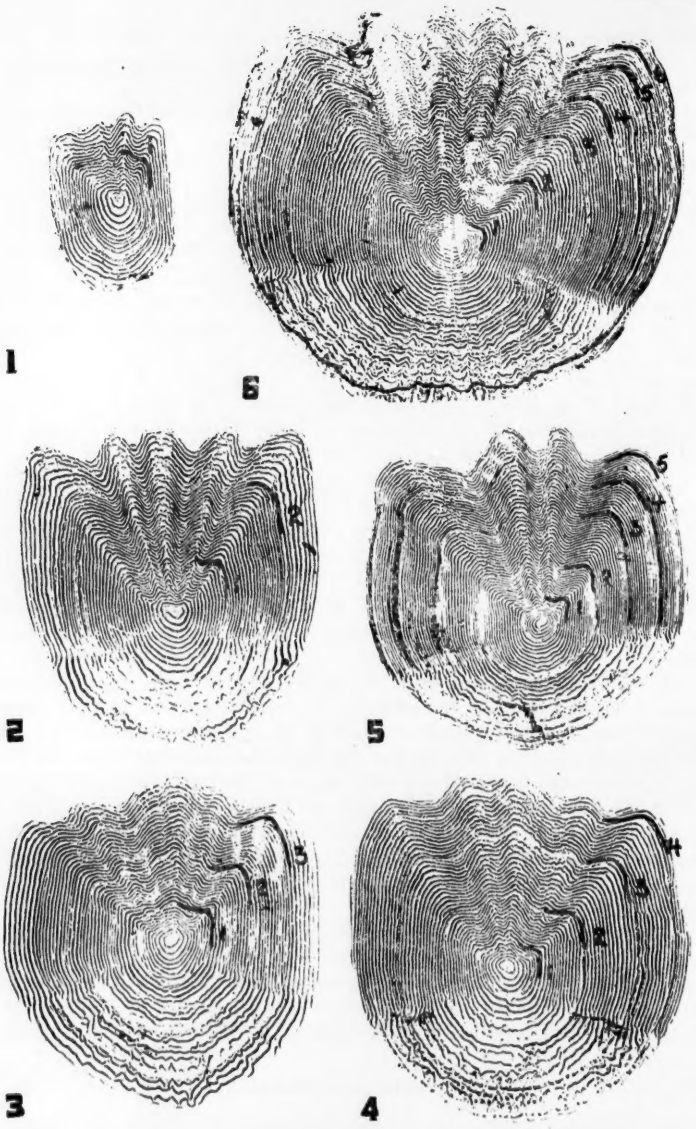
We found grayling in most of the bays of the lake which received streams. Some entered our nets several miles from the nearest stream mouth, but the majority were taken close to, or in the streams themselves. The greatest numbers were seen in the outlet of Great Bear Lake, the Bear River. Here they favoured the very source of the river, the point where it leaves the lake and where the 9 mile per hour current is just beginning. During August the grayling played and leaped here constantly. Literally hundreds were in the air at one time, surrounded by flocks of frustrated gulls futilely endeavouring to catch them and plunging first at one splash, then another, in a sort of frenzy.

Such abundance tempted us to try some fly-fishing; they were easily taken on the fly rod but we felt that accounts of their gaminess were exaggerated. Certainly as a sport fish we would not place them in the same category as trout. But their beautiful blue colouring, wonderful dorsal fin and excellent gastronomic qualities make them very desirable fish.

Material and Methods

We collected chiefly by gill-netting; also by seining and angling. Measurements were made on 104 adults and 44 fry. The adults were measured to the nearest millimetre, fork length. The weight was recorded to the nearest ounce. A scale sample was taken from the left side of each fish midway between the origin of the dorsal fin and the lateral line. Stom-

[1] Published by permission of the Fisheries Research Board of Canada.



Figs. 1–6. Photographs of scales of Arctic grayling

Fig. 1. Arctic grayling captured July 30, 1944, at Yellowknife Rapids, Great Slave Lake, in its second summer. Fork length, 79.5 mm. Fig. 2. Arctic grayling captured August 5, 1945, at source of Bear River, Great Bear Lake; in its third summer. Note false annulus between one and two. Fork length, 280 mm. Fig. 3. Arctic grayling same date and locality as Fig. 2; in its fourth summer. Fork length, 288 mm. Fig. 4. Arctic grayling, same date and locality as Figs. 2 and 3; in its fifth summer. Fork length, 329 mm. Fig. 5. Arctic grayling captured July 20, 1945, Great Bear Lake; in its sixth summer. Fork length, 328 mm. Fig. 6. Arctic grayling, same date and locality as Fig. 5; in its seventh summer. Fork length, 407 mm.

ach contents were examined and recorded but not measured or preserved. Many of the adults were examined for parasites, of which examples of those found were preserved. The fry were preserved in formalin and measured on return to Edmonton.

The scale samples were studied dry under binoculars, then two or three were selected from each envelope, cleaned and mounted in glycerine jelly. Photographs of six scales having from one to six annuli are shown in Figures 1 to 6. The annuli are fairly easy to determine, especially along the antero-lateral radii of the scales. False checks, although common, could readily be distinguished by their position (note Fig. 2), and we feel that our age determination was reasonably accurate.

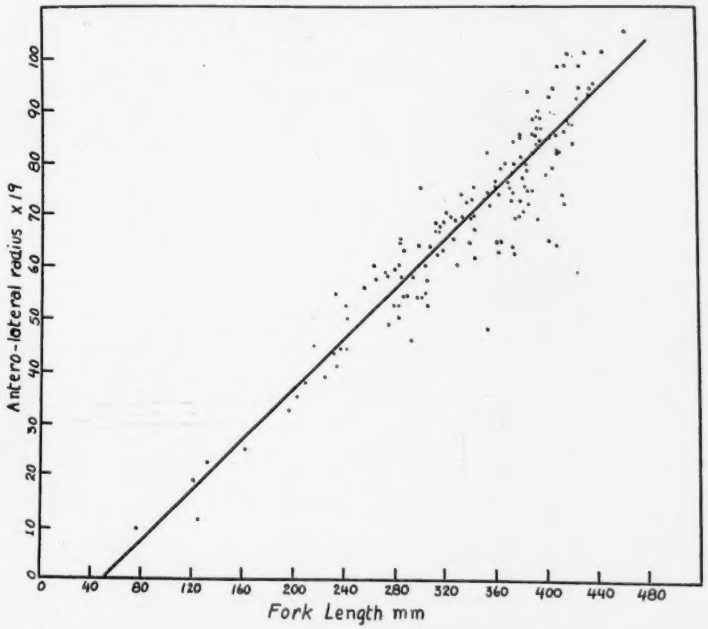


Fig. 7. The relationship between antero-lateral scale radius and fork length.

For calculating lengths of the fish at the end of each year of life images of the scales were projected on a ground glass screen at approximately 19 diameters. The position of each annulus along an antero-lateral radius was then marked on a filing card. The author would prefer to use scale diameters or anterior radii for such work but in many of these scales the annuli could not be distinguished in either the anterior or posterior fields. Figure 7 shows a plot of antero-lateral radii of the scales against fork length (measurements of a small collection from Great Slave Lake and Lake Athabaska are included in the figure). A straight line fits the points reasonably well and a linear relationship between antero-lateral scale

TABLE I

AVERAGE FORK LENGTHS AND WEIGHTS AT CAPTURE AND AVERAGE CALCULATED FORK LENGTHS FOR EACH YEAR OF LIFE OF 100 ARCTIC GRAYLING FROM GREAT BEAR LAKE.

Age (no. of annuli)	Av. length at capture	Av. wt. at capture (grams)	No. of specimens	Average calculated lengths of each age group										
				1	2	3	4	5	6	7	8	9	10	11
1	196	71	1	138.5	—									
2	272	215	3	129.5	214	—								
3	290	269	14	112	193	264	—							
4	317	382	18	87	156	243	298	—						
5	356	519	17	97	157	243	299	337	—					
6	374	624	17	96	159	226	280	324	356	—				
7	393	680	16	93	152	222	277	323	356	379	—			
8	413	793	6	93	152	218	273	320	352	379	402	—		
9	425	935	5	91	143	204	259	301	338	371	396	410	431	—
10	436	1,060	2	88	133	193	253	306	347	377	395	414	442	454
11	462	1,300	1	85	113	223	285	321	364	395	414	430	—	—
Grand average[1]				93	155	231	285	325	353	378	399	410		
Annual increments				93	62	76	54	40	28	25	21	11		

[1] Calculated from 4–9 year olds only.

radius and fork length has been assumed in the calculations. (A plot of scale diameters and fork lengths for these fish does not give a better linear relationship.)

In Figure 7 the downward extrapolation of the curve cuts the axis at a fork length of 50 mm. This figure has been taken for the fork length at time of scale formation. (None of the fry collected had scales; the largest specimen measured 44 mm.) Length calculations were made as follows:

$$\text{Fork length at year } x = \frac{\text{(antero-lateral radius at year } x}{\text{whole antero-lateral radius}} \text{fork length} - 50) + 50.$$

Rate of Growth and Age of Maturity

The observed average lengths and weights and the calculated lengths for each year of life are shown for 100 grayling in Table I. The grand average calculated lengths in this table were derived from four- to nine-year-old specimens only. The data show clearly that our nets were selecting the larger fish of the younger age groups (Lee's phenomenon); a truer general growth picture may be expected from the middle range of ages.

Table II

Average Fork Lengths, Average Weights at Capture, and Average Calculated Fork Lengths at the End of Each Year of Life for 23 Arctic Grayling from Great Slave Lake

(No. of annuli) Age	Av. fork length (mm.)	Average weight (grams)	Number of specimens	Average calculated length						
				1	2	3	4	5	6	7
1	124	57	4	100	—					
2	231	170	13	100	187	—				
5	405	737	4	113	191	264	324	367	—	
6	394	680	1	133	179	224	303	340	370	—
7	438	1,050	1	99	165	242	320	365	397	425
Grand average				104	186	254	314	362	—	—

Table III

Average Fork Lengths, Average Weights at Capture, and Average Calculated Fork Lengths at End of Each Year of Life for 15 Arctic Grayling from Lake Athabaska

Age (No. of annuli)	Average length (mm.)	Average weight (grams)	Number of specimens	Average calculated lengths at end of each year					
				1	2	3	4	5	6
2	286	226	6	119	206	—	—	—	—
3	312	340	2	119	195	268	—	—	—
5	378	652	4	107	190	262	310	352	—
6	394	680	3	98	160	233	296	345	375
Grand average				112	191	254	304	349	—

In Tables II and III, observed and calculated fork lengths for 23 Arctic grayling from Great Slave Lake and 15 from Lake Athabaska are

shown. The measurements and scales of these fish were very kindly sent to us by Dr. Rawson, of the University of Saskatchewan.

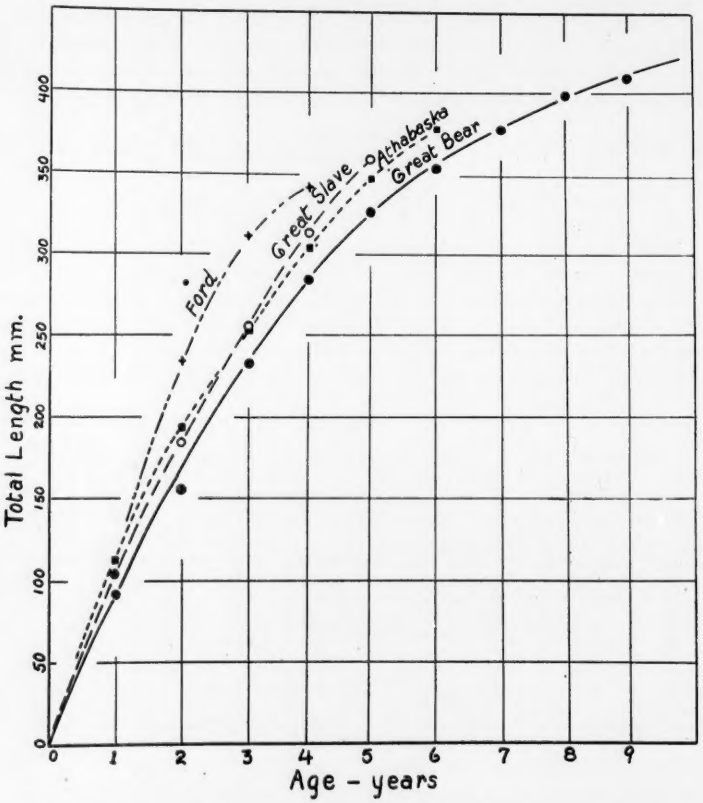


Fig. 8. Growth curves for Arctic grayling from Great Bear, Great Slave and Athabaska lakes and for Montana grayling from Ford Lake, Michigan.

In Figure 8 the average calculated fork lengths for Great Bear, Great Slave and Athabaska grayling are plotted against age in years. Also included on the graph are Brown's data (1943) for Montana grayling from Ford Lake, Michigan.[2] Because of the small numbers of fish from Great Slave Lake and Lake Athabaska the curves for these two lakes are probably not very significant; it seems beyond doubt, however, that the grayling in these lakes grow a little faster than in the more northern Great Bear Lake. The Ford Lake grayling grow the fastest (the poor showing of these fish in the first year is due, as explained by Brown, to time spent in the hatchery).

[2] Hubbs and Lagler (1941) regard the Montana grayling as *Thymallus signifer tricolor* Cope.

What strikes the author as remarkable is the smallness of the difference in growth rate between the Ford Lake and Great Bear Lake grayling. In spite of the intense cold and short growing season the Arctic grayling achieves very good growth. This is surely a most impressive example of an animal truly adapted to an Arctic climate.

The average weight at time of capture for each age group is included in Table I. The single fish in its second summer weighed 2.5 ounces (71 grams); most of the fish weighed from 1.0 to 1.5 pounds, the largest fish, in its twelfth summer, weighed 46 ounces (1300 grams).

TABLE IV

THE AVERAGE CALCULATED FORK LENGTHS (MM.) OF 34 MALE AND 44 FEMALE ARCTIC GRAYLING FROM 4—9 YEARS OLD AT THE END OF EACH YEAR OF LIFE

Age	1	2	3	4	5	6	7	8	9
Males	94	152	226	279	320	356	381	403	416
Females	92	155	232	289	328	349	372	395	402

There may be differences in growth rate between the sexes, but the numbers of specimens are probably too low to make them evident (Table IV).

None of the grayling fry collected had developed scales. Six larger fry, collected July 13, were found in a protected bay where water temperatures were a few degrees higher than average. The record of the fry collected is summarized in Table V.

TABLE V

FORK LENGTHS OF 44 ARCTIC GRAYLING FRY FROM GREAT BEAR LAKE

Date	No. collected	Av. length	Largest	Smallest
July 16	3	25	27	22
July 20	35	25	29	20
July 13	6	38	44	35

Some grayling reach sexual maturity during their fourth summer, i.e., as three-year-olds. Of the 14 three-year-olds which we examined, 5 (2 males and 3 females) were mature. Of the other 9, 6 were immature and 3 had gonads larger than immature fish but smaller than typical mature fish. Among 18 four-year-olds there were still 2 immature fish and 5 with intermediate type of gonads. None of the fish older than four years was definitely immature, although 3 five-year-olds and 1 each of the six-and seven-year-olds had small intermediate type of gonads. These fish with the intermediate gonads are possibly fish which had spawned during the past spring and which were not going to spawn in the coming season. There is evidence that the lake trout in Great Bear Lake spawn only every other year or even less frequently (Miller and Kennedy, in preparation).

The oldest Montana grayling seen by Brown (1943) was in its sixth year of life. He found that, in general, grayling started disappearing from waters where they had been introduced during their fourth summer, and vanished almost completely in their fifth. These observations suggest very early maturity. Brown states, "Rapid growth and a short life appear, therefore, to be characteristic of this species." It is interesting to contrast the condition in the Arctic, where collections included fish in their twelfth summer, and where the majority of the population matures in the fifth summer—about the age when the southern fish have completed their lives.

Food

The stomachs of 103 grayling were examined and the food items found were recorded. Only one stomach was empty. No quantitative measurements of stomach contents were made; materials were simply sorted over, identified and discarded. The findings are summarized in Table VI.

Table VI

Stomach Contents of 102 Arctic Grayling, in Percentage of Total Specimens

	Per cent		Per cent
Terrestrial insects (total)	93.0	Fish (total)	10.8
Bees and wasps	2.9		
Grasshoppers	16.6	Unidentified	8.8
Ants	29.4	Grayling[1]	0.9
Beetles	14.6	Ciscos	0.9
Bottom organisms (total)	21.6	Plankton (total)	26.5
Chironomidae	2.9	Copepoda and Cladocera	20.6
Caddis larvae	3.9	*Mysis relicta*	5.9
Mayfly nymphs	5.9		
Pontoporeia	7.8	Miscellaneous (total)	13.7
Snails	0.9	Lemmings	0.9
		Fish eggs	0.9
		Gordius	6.9
		Onions and corn[2]	0.9
		Gravel	3.9

[1] Fish of the year; several unidentified remains are probably also grayling fry.
[2] Refuse from tug boat.

The food items included in Table VI represent only the summer diet of the grayling. The principal food, terrestrial insects which they take from the surface, is, of course, not available at other seasons. Grayling are opportunists as far as food is concerned. All available food items are utilized—terrestrial insects (93% of stomachs), bottom organisms (21.6% of stomachs), fish (10.8% of stomachs) and plankton (26.5% of stomachs); any and all miscellaneous bits of food are taken—kitchen refuse from a boat; horse-hair worms (*Gordius*), fish eggs, baby lemmings (mammals) and even their own young. Single stomachs very often contained terrestrial insects, plankton and bottom organisms mixed, thus demonstrating the very general nature of the diet.

Leonard (1939 and 1940), in his studies of the feeding habits of Montana grayling in Ford Lake, Michigan, showed that predaceous insect larvae were the most favoured food. He found very little use of terrestrial insects. In this respect the Arctic grayling differ considerably. Dr. Rawson, in an unpublished report on the fish of Great Slave Lake, writes that the grayling "feed largely on insects but some of the stomachs examined were gorged with amphipods." The Great Slave grayling appear to resemble the Great Bear grayling in feeding habits.

Parasites

A small collection of parasites was made from 98 Arctic grayling. The collection includes Cestoda, Nematoda, Acanthocephala and Copepoda. The principal findings are listed in Table VII.

Table VII

Parasites from 98 Arctic Grayling of Great Bear Lake

Parasite	Location in host	Abundance
Cestoda		
Triaenophorus crassus Forel	encysted in epaxial muscles	8 infested fish
Triaenophorus nodulosus (Pallas)	encysted in visceral peritoneum	only one found
Cyathocephalus sp.	adults in stomach	numerous specimens in one fish
Nematoda (unidentified)	encysted in visceral peritoneum	found in several fish
Acanthocephala		
Echinorynchus coregoni Linkins(?)	in stomach	found in one fish
Copepoda		
Salmincola thymalli (Kessler)	gills	found in one fish

Acknowledgments

I am particularly indebted to Dr. W. A. Kennedy, of the Central Station of the Fisheries Research of Canada, who accompanied me in the field. Dr. Kennedy was chiefly responsible for operating the gill nets and obtaining the fish. Thanks are also due to Dr. D. S. Rawson, of the University of Saskatchewan, who allowed me to use his grayling material from Lake Athabaska and Great Slave Lake.

Summary

1. During the summer of 1945, a collection of 104 Arctic grayling was made from Great Bear Lake, the source of Richardson's type specimen, which had been taken in 1836.

2. The average fork lengths at the end of each year of life have been calculated from scale samples.

3. Considering the climate, the rate of growth is remarkably fast. The length of life is about three times that of the Montana grayling and the ultimate size reached is greater. Maturity is attained relatively late, i. e., during the fourth and fifth summers.

4. A study of the stomach contents of 102 fish reveals a very mixed diet: grayling utilize all food sources in the lake. In summer, terrestrial insects are favoured.

5. A list of parasites is given.

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On the Mating Behavior of Free Garter Snakes Associated with Water

By C. M. Breder, Jr.

FIELD observations on the mating behavior of snakes in an entirely free and non-captive state have not been often reported. Those that have been are mostly brief observations evidently made in passing. Reports on captive animals are more extensive and detailed but as always with such observations there is no way of determining clearly whether the behavior is normal and typical or more or less distorted by the environment of captivity. For these reasons when vigorous attempts at mating became apparent in a small colony of *Thamnophis s. sirtalis* Linnaeus, which is composed of volunteer residents on the author's property, other matters were dropped and nearly continuous observations were made on this behavior for three days, which covered the full period of activity.

When this property was acquired in 1936, specimens of this species were noted each summer from time to time and no other snake species has ever been seen on the property, nor is it believed that any are resident. The following year a small lily pool was constructed and its immediate vicinity planted rather densely, mostly with native ferns and flowering plants. No snakes have ever been seen at a point very remote from this spot since. It became a matter of policy not to molest them in any fashion in these nine years to see if they would become less timid as they evidently have, for in the last several years we have been in fear of accidentally treading on them since they are generally loath to move out of the way of persons. A single exception to this "no handling" policy occurred in 1945. A considerable population of *Rana clamitans* (Latreille) has also established itself in the area. One warm August afternoon one of these emitted a series of calls such as they sometimes give when frightened or handled. It continued for so long a time that out of curiosity the frog was sought out. One of the snakes was found to have caught the frog by one thigh; it was clearly much too large for the snake to manage and evidently the snake was unable to disengage its fangs. The two were lifted and separated. Incidentally, whatever may be said of the utility of this "distress" call of *Rana clamitans* this time, at least, it evidently *did* have survival value for the frog. The snakes appear from hibernation and sun themselves on warm days in March or April. The following early dates were noted: April 24, 1942, April 9, 1944, March 30, 1945, March 16, 1946. No other especial activity was noted until this year when the following observations were made.

On May 24 at about 2:00 P.M. reproductive activity was well under way when first noticed. Five snakes were involved in the procedure and these probably represent the entire adult population of this colony. Two were females and 3 males, as was subsequently found, and the sexes were readily separated on a basis of size, the females being considerably larger than the males.

A very definite behavior pattern in the search for mates, associated with the pool, was apparent. Both females were stationed at the water's edge, resting passively and each facing the pool. The 3 males were all swimming along the shore line and examining it continually, intermittently stopping and closely going over an area by tongue, about as far as 6 inches from the water line. This part of the activity was so regular and well patterned that it could not be considered merely accidental but so far as this colony is concerned seemed to be a formalized procedure. The general situation is indicated in Figure 1 and typical swimming activity is shown in Plate I. The photograph in the lower right-hand corner shows a male coming in to shore to examine an area by tongue.

The difficulty these males had in locating the females was marked. They clearly were unable to follow trails as described by Davis (1936) for *T. radix* Baird and Girard, and by Noble (1937) for the present form in dry places, since they were in the water and the females seem to have either reached their resting places by swimming to them or by an approach directly toward the pool. The other possibility would be that if they crawled about considerably along the shore line, much of this area would

have been a confusion of mixed trails of scent. Sometimes the males would pass within a few inches of a female and then go on, only to touch her accidentally before recognition was established. At other times the touch of the tongue appeared to establish recognition. They seemed to be aware of the general area in which a female was located but the establishment of her exact position presented somewhat of a problem. Noble (1937), in discussing the role of vision in such connections, as indicated by the reactions of the male in response to movements of the females, pointed out that without such movement visual cues were absent. As these females sat passively, although in full view, sight was of no aid in the finding of mates. Evidently smell offered some sort of general guide, while contact seemed to be definitive.

This exploratory activity was carried out in a "nervous" manner, but as soon as contact was established the whole behavior altered radically. At once the male became deliberate and "cautious." All tongue flicking ceased. He would glide slowly toward the female, first finding her head, which due to her position was toward the water and the approaching male. Then, typically he would place his noticeably smaller head immediately behind hers and generally a little to one side. Following this he would slowly "loop" his body along hers, following closely the contours in which she happened to be lying. When this was accomplished his cloacal region would make exploratory movements attempting to locate the cloacal opening of the female. This was frequently a prolonged process which in all behavior noted in detail included the necessity of some backing by the male so that when the connection was possible his head was much farther back than where originally placed. The position of an embraced pair in all its variations was clearly determined by the position in which the female happened to be lying prior to approach. They evidently struck no especial pose as pairs were seen in many positions from well coiled and looped to nearly straight. The actual details of the mating checked closely with those described by Noble (1937), as far as such were evident, but the chin rubbing by the male along the back of the female was reduced to a minimum. This may be associated with the frontal approach incident to this water edge mating. The series of six photographs in Plate II shows successive steps from the approach of a swimming snake to the attainment of cloacal contact. The interval between the successive pictures is between 10 and 20 seconds.

During all this activity the female would lie with complete passivity, but when the male reached the cloacal region and evidently attempted insertion of the hemipenis, more often than not the female would dash off, swimming about for a short time, with the male in pursuit. She would quickly lose him and re-station herself at some other place along the shore, while the male would resume his searching activities. If a pair did not break up in such fashion, another source of disruption would frequently be the finding of the female by another exploring male. On the first day of observation this always resulted in an explosive separation. Evidently none was successful in carrying copulation through to conclusion as at no time were any of the males dragged about, but all broke instantly when the female moved off.

On the second day, at 9:00 A.M., all 5 snakes were found in a tangled group near the water inlet as indicated at "5" in Figure 1. The males were making desultory attempts at copulation. By noon they had separated and were distributed about as on the previous day. At 12:45 one pair was mating at location "6" in Figure 1 and ten minutes later another

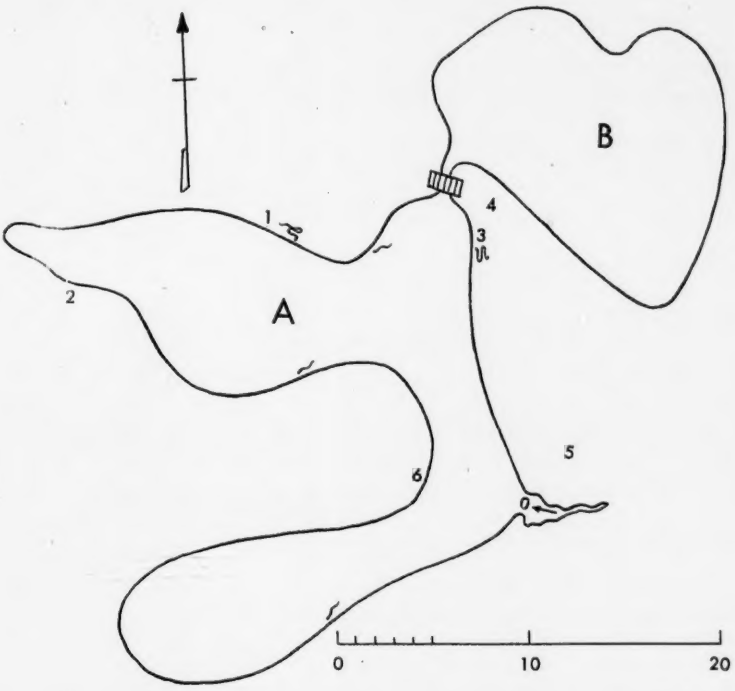

Fig. 1. Sketch map of site of activity, showing the three swimming males and the two stationed females at the height of the searching behavior. Scale in feet.

A. Pool which contained nearly all the activity. B. Pool which was visited once by a single male on the second day. 1. Site of two separate matings on the first day. 2. Site of two separate matings on the first day. 3. Site of two separate matings on the first day and one on the second. 4. Site of two separate matings on the second day. 5. Site of the "snake ball" on the second day. 6. Site of a polyandrous mating.

male joined the 2 but this time it did not lead to dispersal. The new male attempted to mate also, from the other side of the female. They separated at 1:05 and the males resumed their typical searching activities. The 3 appeared very like those in a photograph shown by Noble (1937). At first it was thought that both had established entry but the ease with which they separated would seem to make this unlikely. Such attempts have been reported by a number of observers on various species, Brennan (1924) and Noble (1937) making such notes on this particular form.

At 2:45 another pair attempted mating but soon gave up. The ac-

tivity was clearly subsiding. The females moved farther back from the water's edge and the males widened the area of their searching, one even swimming about in a second pool where there had been no activity up to this time, as indicated by "B" in Figure 1. [1]

The following day observations were continued but the females kept well back from the water and the more active males were not seen to enter the water although they continued to prowl near the pool's edge. By 3:10 no snakes were to be seen at all. Evidently the entire activity was finished. The next several days were marked by almost continual rain. The conditions of temperature during these observations are given in Table I.

TABLE I

TEMPERATURE RECORDS

Degrees Fahrenheit

Date	Hour	Air	Water
May 24	8:30 A.M.	62	57
	2:00 P.M.	82	69
25	11:30 A.M.	78.5	—
	12:15 P.M.	80	—
	12:35 P.M.	81	68
	1:05 P.M.	83	—
	4:30 P.M.	85	—
26	9:00 A.M.	75	67
	12:00 noon	80	—
	1:45 P.M.	81	—
	2:20 P.M.	84	—
	3:10 P.M.	84	—
	3:30 P.M.	83	74

The three days on which these observations were made were very hot, practically "mid-summer" conditions following a protracted cool and rainy period. This condition may have had the effect of concentrating a continually delayed activity, which perhaps in a more normal spring would have been much more dispersed in time and less readily noticed.

It is obvious that the swimming search behavior could only be undertaken in certain localities, but since this species is more abundant near water than remote from it (Ruthven, 1908), this may actually be a common behavior pattern. That it is not a necessary concomitant to mating is evident from the behavior of captive specimens and from field observations remote from water. For example, Bishop and Alexander (1927) reported mating on a low branch of a hemlock tree. At the time the present observations were being made a report came from about a half mile away in a dry wooded area of a "snake-ball" which was evidently a group, similar to, but larger than, the one we noted the second morning.

In all there were ten attempts at mating, including one polyandrous attempt in addition to the "snake ball." For these efforts only five sites were used, as is indicated in Figure 1. Three of these sites were used twice each, one once and one three times. This does not mean that these were

[1] Mr. C. M. Bogert, who was kind enough to read and criticize this manuscript, was able to visit the area just in time to witness some of this terminal activity.

PLATE I

MALES IN THEIR EXPLORATORY SWIMMING ACTIVITY IN SEARCH OF MATES

POOLSIDE MATING BEHAVIOR

Upper left. A female at her station. Site "3" of Fig. 1. *Middle left.* A swimming male detects the female. *Lower left.* The male immediately places his head just behind that of the female. *Upper right.* The male loops his body progressively in alignment with that of the female. *Middle right.* The male attains complete alignment. *Lower right.* The male moves backward so that the cloacas can meet.

the only possible choices available for actually nearly the entire shore line was sufficiently free to be usable. In some the snakes were not only visible, but definitely conspicuous while in others they were rather well sheltered by leaves. It would be very difficult to determine the various factors that led to the use of any one of the sites. The "snake ball" was perhaps most conspicuous of all, resting on a mat of very pale green carpet-like growth which fully supported its weight. Site "4" was in the middle of a gravel walk and here alone did trail following enter into the mate-seeking activities. The photographs in Plate I give an idea of the nature of the shore line in the other mating attempts.

Since obviously the opportunity of trailing females by means of scent trails was all but entirely suppressed in this aquatic activity, the question remains as to why the snakes took up such a mode of behavior. It would, at least, not seem to be forced by any environmental strictures because at the east end of pool "B" there is an open vegetable garden and within a distance of 50 feet of the pools there is, in addition, a lawn, a flower bed and an open pasture, all of which might be supposed to be attractive to garter snakes. It might be imagined that females not yet ready for mating could learn that if they swam through some water their trail would become lost, which might account for the positions they took along the pool edge, presumably for the purpose of sunning themselves. Then it might be further imagined that the males could be capable of learning of this and reacting as witnessed or that in following a trail to the water they merely plunged in and continued along the shore line, which because of the small confines of the pool, was peculiarly successful. That is to say that even with the trail lost a continual circumnavigation of the pool, with repeated passing of any given point, eventually led to locating a female in spite of the sensory restrictions imposed. In larger bodies of water this would presumably not operate in such a fashion, the shore line leading the males far away from a female and not quickly to the other side of the pool or stream. It should be interesting to make further observations in areas where there are small natural ponds of sizes comparable to these lily pools.

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Effects of Snake Venoms on Snakes

By Paul L. Swanson

In 1931 I started a series of experiments on snake venoms in order to procure comparative data on the effects of venoms on various species of snakes. The war brought the work to a standstill in 1941, after I had concluded 58 experiments. Although the small number of experiments does not permit definite conclusions to be drawn, the work is now summarized due to the improbability of its being continued to any extent in the near future.

The experiments were performed in widely scattered places wherever snakes were available; freshly extracted liquid venom was always used. It was collected in a rubber covered glass graduate, measured, and injected with a hypodermic syringe. All instruments were sterilized by boiling before use, and control experiments were made by injecting sterile distilled water in the same manner as venom in the regular experiments. The specimens injected were under observation for at least a week afterward; when death ensued, autopsies were usually made, and the internal organs macroscopically inspected. These post-mortem examinations were not more thorough than was necessary to ascertain definitely that death was toxic rather than traumatic.

Since the exact amount of toxic constituents in liquid venom can not be determined accurately, quantitative comparisons are only approximate. However the use of such venom simulates more naturally actual snake bites.

Air temperatures, time of day, source of snake injected, source of snake from which venom was extracted, time of various symptoms, and the results of the autopsies were recorded. These data are abstracted below.

The choice of snakes used in the experiments was based more on expediency than desirability. In some experiments the venom from as many as 7 snakes was used in one injection. In connection with this series of experiments, I made 134 venom extractions. Venom yields ranged from none at all up to 21 minims (1.26 cc) from a *Crotalus atrox*. Twenty extractions from *Sistrurus catenatus catenatus* yielded from .25 to 2 minims each, averaging about 1.2 minims (0.07 cc); 37 extractions from *C. horridus horridus* varied from 0 to 6 minims, averaging about 2.8 (0.18 cc); 46 extractions from *Agkistrodon mokeson mokeson* showed a variation from .50 minim. to 4.5 minims, averaging about 2.5 minims (0.15 cc).

Extractions were also made from *Agkistrodon piscivorus*, *A. mokeson laticinctus*, and *Crotalus atrox*, but the specimens used were too few, too small or were used without a proper rest period, to supply any pertinent figures. My results do not show any great divergence from other published figures on venom yields from these species. Whenever the same snakes were used for several extractions, subsequent extractions were never made within a period of less than two weeks.

I am grateful to Clinton Coulter, M.D., for assisting me in initiating the work, and for establishing a method of procedure in injecting and autopsying, and to Arnold J. Schauman, David C. Swanson, and Mrs. Eva Henderson, who aided me from time to time.

Experiments with Venom of *Crotalus horridus horridus*

1. Injected into *Crotalus horridus horridus.*
   a. 7 minims injected into a rattler about 900 mm. in length resulted in no apparent symptoms.
   b. 5 minims injected into a 914 mm. specimen, and
   c. 7 minims into a 762 mm. rattler showed no noticeable effects whatsoever, and the rattlers fed on rats 13 days later.
   d. A 762 mm. rattler was forced to bite itself by pressing the fangs into the back muscles and massaging the glands. No symptoms developed. These four experiments indicated that the species is immune to its own venom, but a fifth, on
   e. a 705 mm. snake, into which 10 minims were subcutaneously injected, resulted in its death. Part of the venom was its own. For 3 days the snake acted normally, but on the 4th it became sick and was unable to lift its head from the ground; 75 hours after the injection it was dead. No swelling was noted, although there was some destruction of tissue within a 50 mm. radius of the injection. Anterior lobes of the heart were very dark, posterior pale. Otherwise the organs appeared normal.
2. Injected into *Agkistrodon mokeson mokeson.*
   a. 3 minims injected into a juvenile specimen (about 240 mm.) killed it in 17 hrs. 25 minutes.
3. Injected into *Sistrurus catenatus catenatus.*
   a. 4 minims injected into a 240 mm. massasauga resulted in no immediate symptoms. In 2 days it began to gape and appear very weak, and death ensued 53½ hours after the injection. Some general edema present.
   b. 4 minims injected into another 240 mm. massasauga resulted in death in about 18 hours. Internal hemorrhages present.
4. Injected into *Thamnophis sirtalis sirtalis.*
   a. 3 minims injected subcutaneously into a 425 mm. specimen resulted in considerable swelling; 24 hours later the snake was very weak. In 48 hours it became stronger and drank water long and greedily. It expelled a bloody fluid from the mouth. In 80 hours the swelling had subsided, the snake was stronger and apparently recovering. At 96 hours I killed it; there were slight evidences of internal hemorrhages.
   b. 2 minims were injected into a 430 mm. specimen. Apart from slight local symptoms, there were no effects noted, and recovery was complete.
5. Injected into *Elaphe obsoleta obsoleta.*
   a. 5.5 minims were injected into a 1676 mm. specimen subcutaneously near the heart region. Three days later it shed normally; 5 days later it was released in apparent good health. No symptoms were noted.
   b. 5 minims were injected intramuscularly into a 1041 mm. snake, anteriorly. Some edema was noted; 40 hours later it was in evident pain, the anterior part of the body was badly swollen, the mouth gaping, and the snake having muscular spasms; 41 hrs. 25 min. after the injection it was dead. It was bleeding freely from the trachea prior to death. The fore part of the body was swollen to almost double its normal size. Practically all the internal organs showed severe hemorrhages, and there was much free blood in the abdominal cavity.
6. Injected into *Coluber constrictor constrictor.*
   a. 3 minims were injected into a 1422 mm. specimen with no apparent effects, although the snake was under observation for 2 weeks.
   b. 12 minims injected into a 901 mm. specimen resulted in muscular inco-ordination within 4 hours. At 7 hours there was some local swelling, and the racer was lethargic. At 24 hours it seemed no worse, but at about 48 hours it died, rather unexpectedly. There was severe destruction of tissue at the site of the injection, and the lung and heart showed hemorrhage.
7. Injected into *Heterodon contortrix.*
   a. 4 minims were injected intramuscularly into an adult snake of about 580 mm. No symptoms were noted, and 6 days later the specimen fed normally on two toads.

8. Injected into *Storeria dekayi*.
   a. 1 minim injected into a 280 mm. specimen subcutaneously resulted in death in 4 hours and 5 minutes.
   b. 2 minims injected into a 285 mm. specimen in the same manner and site (anterior dorso-lateral) resulted in its death in 4 hours, 4 minutes.
   c. 4 minims injected into a 307 mm. individual as above, caused death in 4 hours and 18 minutes.

Experiments with Venom of *Crotalus atrox*

1. Injected into *Crotalus atrox*.
   a. 21 minims were injected subcutaneously into a 1016 mm. rattlesnake. It appeared normal for the first 24 hours, in fact seemed a little more active than usual; no external symptoms. However 26 hours and 50 minutes after the injection it was dead. Collapsed lung and much extravasation of blood into the abdominal cavity.

Experiments with Venom of *Agkistrodon mokeson mokeson*

1. Injected into *Agkistrodon mokeson mokeson*.
   a. 2.5 minims were injected subcutaneously into the same 654 mm. copperhead from which it was extracted. For the first 2 hours a slight swelling was noted at the site of the injection. No other effects were noticed. The snake subsequently shed normally and lived in a healthy condition for many months.
   b. 1.5 minims were injected subcutaneously into a 228 mm. copperhead, which became very weak within a few hours, and died in 6 hours. The lungs, heart and body cavity were bloody, showing unmistakable signs of venom action.
   c. As most of my injections were made in the anterior third of the body, the next copperhead, 236 mm., was injected intramuscularly in the tail. It showed effects very quickly. In a little over an hour muscular spasms and inco-ordination were in evidence, and it died in 1 hour and 33 minutes. The autopsy showed slight hemorrhages and a small bloody spot on the heart muscle.
   d. 13 minims of venom from 7 copperheads was injected subcutaneously into one of them, a 660 mm. male, near the heart on the right side. The temperature was fairly uniform at about 68°F. The snake gradually became sluggish and weak until it died 24 hours later. The post mortem showed the posterior two-thirds of the body practically unaffected. The anterior portion of the body cavity contained much free blood; the trachea showed severe bleeding; lung deflated and in bad condition; heart very dark; the muscular tissue within a radius of 35 mm. from the injection was infused with blood from severe hemorrhage. No edema at any time.
   e. 2.5 minims injected into the same copperhead from which it was extracted, intramuscularly. No symptoms whatsoever.
   f. 5 minims, including its own, injected subcutaneously into a 812 mm. specimen in the dorsal region over the heart. Under observation for over a month, but showed no ill effects.
   g. 4 minims injected subcutaneously into a 240 mm. specimen was followed by ill effects immediately, and the snake died 15 minutes later.
   h. Slightly less than 2 minims injected into another 240 mm. specimen resulted in its death in 20 minutes.
2. Injected into *Agkistrodon piscivorus*.
   a. 5 minims injected subcutaneously near the heart into a 259 mm. moccasin resulted in death 35 minutes later. Autopsy showed muscles slightly bloodshot at site of injection; heart pale; lungs collapsed; loose blood in body cavity. Violent internal effects.
   b. 2.5 minims injected subcutaneously into a 254 mm. moccasin caused gradual weakening resulting in death 7 hours and 42 minutes later. Post-mortem: skin badly wrinkled at site of injection, more so than in any other of 49 experiments preceding this one; muscles bloody around injection; heart pale; much blood in body cavity; lungs and liver showed severe hemorrhages.

3. Injected into *Sistrurus catenatus catenatus.*
   a. 4.5 minims injected subcutaneously into a 237 mm. massasauga resulted in immediate effects. The snake squirmed and in about 5 minutes paralysis began; in 8 minutes it was quite weak; at 11 minutes it crawled only with great difficulty; in 33 minutes it could not crawl at all; in 1 hour only slight movement was possible; death in 1 hour and 5 minutes. Hemorrhages of internal organs; muscles dark; no swelling.
   b. 5 minims injected into a 258 mm. massasauga caused reactions immediately, in the same manner as the preceding. Death occurred in 47 minutes. Autopsy showed results as in 3a.
4. Injected into *Crotalus horridus horridus.*
   a. 7 minims were injected into a 900 mm. rattler intramuscularly, with practically no immediate symptoms. The following day the snake acted rather sluggish and made unusual attempts to strike, but was plainly disco-ordinated, as the strike was wobbly and in "slow motion." It gradually became weaker and died 29 hours and 50 minutes after the injection. Autopsy showed severe hemorrhages of the internal organs.
5. Injected into *Natrix sipedon sipedon.*
   a. 9 minims were injected into a 615 mm. water snake. It writhed considerably following the injection, and in a half hour there was local swelling. In 1 hour and 42 minutes the snake was dead. Usual post-mortem findings.
6. Injected into *Coluber constrictor constrictor.*
   a. 13 minims injected subcutaneously, posterior to heart, into a 1083 mm. racer, resulted in its death in 3 hours and 32 minutes. Violent internal hemorrhages in the vicinity of the heart; little if any effects elsewhere.
   b. 3 minims injected subcutaneously into an 800 mm. racer caused only slight local reaction. The snake recovered completely, and subsequently shed normally.
7. Injected into *Elaphe obsoleta obsoleta.*
   a. 8 minims given subcutaneously to a 1400 mm. pilot blacksnake resulted in death in about 2 hours. It felt the effects immediately and was very weak in a half-hour. Autopsy showed few internal effects; slight hemorrhage on one lobe of the heart. Little if any effects elsewhere.
8. Injected into *Lampropeltis triangulum triangulum.*
   a. 10 minims of venom were injected into an adult of 750 mm. Immediate local swelling, which gradually spread. Inco-ordination at about 7 hours; 13½ hours later bleeding occurred at site of injection with swelling receding; in 20 hours, purulent exudate was oozing from site, otherwise the snake appeared well enough; 29 hours and 45 minutes after the injection it died. Autopsy: lung collapsed; liver bloody; free blood in abdominal cavity; outer epidermis at injection site sloughed.

Experiments with Venom of *Agkistrodon piscivorus*

1. Injected into *Agkistrodon piscivorus.*
   a. 5 minims injected subcutaneously into a 580 mm. moccasin resulted in no apparent ill effects.
   b. 5 minims injected into a 560 mm. moccasin intramuscularly resulted in no apparent ill effects. The snake ate a toad two days later.
   c. 2 minims injected subcutaneously into a young 269 mm. moccasin caused no immediate reaction, but about 7 hours and 30 minutes later it was obvious that the venom was taking effect. Death came at 8 hours and 32 minutes. Autopsy: muscles bloodshot at site of injection; lung collapsed; much free blood in abdominal cavity; heart not as pale as in many other examples. Effects were somewhat localized to the vicinity of the injection.
   d. 4 minims were injected subcutaneously into a 244 mm. moccasin, of which about 1 minim oozed back out of the puncture. In 1 hour and 30 minutes the skin became very wrinkled at site of injection. In 2 hours and 45 minutes the snake became muscularly inco-ordinated. In 4 hours and 45 minutes it was very weak, and died 5 hours and 30 minutes after the injection. Autopsy: liver blood streaked; muscles at injection bloodshot, elsewhere normal; heart pale; free blood in abdominal cavity. Effects rather violent. No swelling.

e. 8 minims injected subcutaneously into a 247 mm. moccasin resulted in immobility in 1 hour and 30 minutes; in 1 hour and 43 minutes it was dead. Autopsy: free blood in abdominal cavity; heart pale; muscles pale; no swelling; lung collapsed. Violent internal effects.

f. 3 minims of its mother's venom injected subcutaneously into a 244 mm. moccasin. For an hour the snake was fairly active and showed no ill effects. It died in 2 hours and 32 minutes. The autopsy showed results the same as in 1e.

2. Injected into *Agkistrodon mokeson mokeson.*

a. 1.5 minims injected subcutaneously into a 225 mm. copperhead resulted in no immediate symptoms; 6 hours later the site of the injection became badly swollen, and death occurred in 6 hours and 38 minutes. The snake was active until shortly before death. Internal hemorrhages were confined to a small area within a 35 mm. radius of the site of the injection.

b. 1 minim injected intramuscularly into a 225 mm. copperhead caused death in 10 hours and 10 minutes. Slight sloughing of skin at site of injection. Autopsy: hemorrhage of liver; lungs normal; 2 dark bloody spots on heart.[1]

c. 4 minims were injected subcutaneously into a 355 mm. copperhead, which died in 1 hour and 26 minutes. Autopsy: lungs bloody; muscles pale; heart very pale; liver bloody; other organs apparently normal; no edema. There was no free blood in the body cavity, as was usually noticed with other severe symptoms.

Experiments with Venom of *Agkistrodon mokeson laticinctus*

1. Injected into *Agkistrodon piscivorus.*

a. 3 minims injected subcutaneously into a 235 mm. moccasin made it a little sluggish within 15 minutes, but it could crawl readily enough until about 1 hour and 15 minutes after the injection, when it began definitely to appear weaker. In 1 hour and 30 minutes it expired. Autopsy: free blood in abdominal cavity; heart pale; liver blood-streaked. Effects did not seem as violent as in similar experiments with *A.m. mokeson.*

Experiments with Venom of *Sistrurus catenatus catenatus*

1. Injected into *Sistrurus catenatus catenatus.*

a. 3 minims were injected into a 230 mm. massasauga. Swelling followed in 13 minutes, locally, but subsided in about 50 minutes. It fully recovered from any possible effects.

2. Injected into *Agkistrodon mokeson mokeson.*

a. 2 minims injected into a 230 mm. copperhead resulted in its death 13 hours and 15 minutes later. Severe internal hemorrhages.

3. Injected into *Storeria dekayi.*

a. 1 minim was injected into an adult snake, about 300 mm. in length. It acted normally for several hours, then a small amount of blood appeared at the puncture. It died 15 hours after the injection. Autopsy: peritoneum dark; lungs, heart, and liver bloody.

b. .5 minim injected into a 300 mm. snake caused death in 72 hours.

c. 3 minims injected into a 297 mm. snake resulted in death 50 minutes later, after some local swelling and inco-ordination.

4. Injected into *Natrix sipedon sipedon.*

a. 1 minim was injected intramuscularly into a water snake. No symptoms were noticed for the first 3 hours, then a deadening of the skin occurred within a 6 mm. radius of the injection puncture. At 16 hours this area was larger and accompanied by some swelling. The snake recovered and 7 days later shed its skin, a small patch remaining at the site of the injection for several days.

5. Injected into *Thamnophis sirtalis sirtalis.*

a. 1 minim injected intramuscularly in the paravertebral muscle of a garter snake, 595 mm. in length, produced a trembling when the snake was released. At 16 hours a beginning necrosis at site of puncture. The snake recovered completely.

b. 4 minims injected into a 510 mm. garter snake was followed by swelling which

[1] This small snake placed an efficient bite with one fang in the flesh of my left index finger. On many of these experiments I had no assistance, and it was rather difficult to hold a poisonous snake and inject the venom into it at the same time, particularly when the snakes were small.

gradually spread to both ends of the snake, producing an appearance as though it had gorged itself to its utmost capacity. In spite of this it could move rapidly when handled. About 20 hours later the swelling remained about the same. In 27 hours it appeared in agony, gaping and thrusting the front of its body from side to side. It expired 27 hours and 44 minutes after the injection. Autopsy showed violent internal hemorrhages, especially in the region of the heart. Eye pupils somewhat dilated; trachea bloody. No other specimen showed such extreme external symptoms.

6. Injected into *Lampropeltis triangulum triangulum.*
   a. 1 minim injected subcutaneously into a 698 mm. snake resulted in no noticeable ill effects.

Discussion

In experiments with *Crotalus horridus horridus* venom, average-sized timber rattlers recovered from normal and above-normal doses in four experiments, but a 795 mm. rattler died 75 hours after receiving 10 minims. However, all of these doses included venom from the snake that was being injected. This venom was fatal to massasaugas and copperheads, but not as rapidly as copperhead venom. Some harmless species recovered completely from what would be average doses, although small specimens succumbed. In three tests, *Storeria dekayi* of approximately the same size, death occurred in a little over 4 hours in each, although the dosage was 1, 2, and 4 minims respectively.

A total of 18 experiments with this venom resulted in 9 recoveries and 9 fatalities, ranging from 4 minutes to 75 hours.

Nichol, Douglas, and Peck, in experiments in which 4 *Crotalus molossus* were made to bite one another, showed that death resulted in each. Their tests with *C. atrox*, using the same methods, resulted fatally. A 48-inch *atrox* recovered from 4 minims of venom, while a 29-inch *C. atrox* died in 4¾ hours from 25 minims. Three *C. atrox* injected with 5 minims each recovered. Their experiments were performed in temperatures ranging up to 103° F., while mine were made in temperatures from about 65° to 85° F. It is quite probable that cold-blooded animals would react more rapidly to venoms when the temperature is high, and would possibly succumb to doses that would be assimilated slowly enough at lower temperatures to permit recovery.

My results indicate that average doses of *C. horridus* venom ordinarily do not prove fatal in the same species, although large doses will cause death. The differing results between the experiments of the authors cited and mine may not be so much a matter of temperature as of the source of the venom, with regard to individuals rather than species. It is possible that when a snake receives its own venom, either entirely or mixed with other venom, it has a better chance of recovery. However, in the only case reported by them in which a snake received its own venom, a *C. atrox* that bit itself in the tail, the bite proved fatal in 27 hours.

Experiments with *Agkistrodon mokeson mokeson* venom indicate that copperheads are more susceptible to venom of their own kind than of other venom. Four minims killed a copperhead in 15 minutes; 2 minims in a half hour; 2 minims in 20 minutes, 1.5 minims in 5 hours; all snakes were of comparative sizes. Two minims of massasauga venom on the same sized copperhead took 13½ hours to kill; 3 minims of timber rattler venom took

17 hours; 1.5 minims of moccasin venom took 30½ hours; all on the same sized copperheads. However adult copperheads recover from normal and subnormal doses. A large dose, 13 minims, killed an adult in 12 hours; 5 minims failed to kill an adult, but half of the amount was from the snake injected. Copperhead venom proved fatal to massasaugas, moccasin and timber rattlers, generally taking more time than with copperheads themselves, considering the amounts given and the relative sizes of the snakes. For various species of harmless snakes large doses proved fatal. Ten minims killed a *Lampropeltis triangulum triangulum* in 30 hours. It might have recovered from a normal dose. Unfortunately I had no ophiophagous king snakes for these experiments. A young racer (800 mm.) recovered from a 3 minim dose of copperhead venom, but a 1083 mm. adult succumbed to 13 minims.

It is possible that *Sistrurus catenatus catenatus* is immune to its own venom; a young specimen recovered from 3 minims taken from 2 adults, showing but slight and temporary local swelling. Two minims killed a young copperhead in 13¼ hours, more quickly than 3 minims of timber rattlesnake venom for the same sized copperhead, but not as quickly as copperhead venom itself.

On various species of harmless snakes, massasauga venom proved fatal unless the dose was small in comparison to the size of the snake.

The experiments lead to some interesting conjectures, but are far too few to supply definite conclusions. At the start I had a theory that snakes might be immune to venom of their own kind, and less susceptible to venom from closely related snakes than to that of more distant relatives. Had that proven true, venom studies might aid in solving phylogenetic relationships. The experiments indicate that this theory is untenable. Before starting on these experiments I felt that specific serums against snakebite were much more efficacious than polyvalent ones, but there are some indications that the opposite might be true, particularly where the copperhead is concerned.

Apparently when a certain amount of venom in relationship to the size of the victim is reached, an increased quantity has little or no effect in accelerating the effects on the victim. Large doses of venom produce a general systemic disintegration with few if any local symptoms. Small doses tend to result in localized effects.

There is a possibility that *Sistrurus catenatus catenatus* is immune to venom of its own kind. Of the other species used, none seems immune to venom of its own kind, although small doses might not affect them. The copperhead is actually more susceptible to its own venom than to that of other species.

There is some indication that an individual snake may possess antibodies that can counteract the effects of its own venom, but not that of venom from other individuals of its own species, or even from its individual blood relatives.

"Suicide" from self-inflicted bites seems highly improbable with the snakes under consideration, although at least one *Crotalus atrox* is known to have died of its own venom. Snakes usually seem to be able to survive

what might be considered normal or average doses of venom, although they are not necessarily immune to it.

It is probable that no two venom samples are exactly alike in their composition and potential effects.

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A Collection of Reptiles from Hunan and Anhwei Provinces, China

By BRYAN P. GLASS

WHILE serving with the armed forces in the China Theater, I was able to make a small collection of herpetological specimens from three different localities in the provinces of Hunan and Anhwei, which is now deposited in the Texas Cooperative Wildlife Collection at the Agricultural and Mechanical College of Texas. Pope (1935) shows that no collections have been made from these localities, and several species represent considerable range extensions over those given by him. The collecting sites, with geographic coordinates, are as follows:

Hengyang, Hunan, 26° 55'N 112° 25'E
Chihkiang, Hunan, 27° 15'N, 110° 05'E
Linchuan, Anhwei, 35° 02'N, 115° 21'E (also listed as Shenkiutsi on some maps)

Amyda sinensis (Wiegmann).—This specimen, together with a number of larger ones, was purchased alive from native fishermen at Linchuan who were taking them from the river by use of trained cormorants (*Phalacrocorax* sp.). The specimen agrees with Pope's description of the species and falls within the limits of the range as outlined. The rather distinct tubercles on the back are arranged in definite longitudinal rows. Despite the small size (length of carapace 82 mm.) the plastral markings are so faint as to be almost indistinguishable.

Geoclemmys reevesi (Gray).—A rather old specimen is quite typical, agreeing closely with Pope's description and with the figures published by Mertens (1937). It was procured at Hengyang from a native, who was ignorant of its original source. Since Hengyang is listed as being within

the presumed range of the species, I consider it probable that the specimen was taken locally.

Takydromus sexlineatus meridionalis Günther.—A specimen taken at Chihkiang October 17, 1944, is quite typical, having 4 rows of enlarged dorsal scales and 12 rows of enlarged ventrals. The frontonasal is in contact with the rostral, and all other scutellation is normal. There are only 2 femoral pores, one on each side. Since the nearest locality recorded by Pope is Yaoshan, in southeast Kwangsi, this specimen extends the range northwards approximately 250 miles. It was caught in extremely dense brush on a rice paddy embankment on the side of a steep hill, and was the only individual seen at this locality. This secretiveness and habitat preference may explain its rarity in collections from this region.

Eumeces chinensis chinensis (Gray).—A skink from Hengyang agrees in scutellation of the head with Taylor's description (1936 : 322–324). It has a small postnasal, abnormal in appearance, on the right side, but none on the left. The lizard is apparently quite old, as there is no indication whatever of any median dorsal stripe. The dorso-lateral light lines involve the lateral edge of the second dorsal scale row, and the bulk of the third row. The lateral dark line is represented by a series of dark scales, each with a light central spot.

Natrix popei Schmidt.—A female specimen, taken near the airfield at Chihkiang October 18, 1944, has the following scale counts: upper labials 8, lower labials 9, preocular 1, postoculars 3, temporals 2 x 2, scale rows 19–19–17, ventrals 136. The overall length is 328 mm., but the tail is incomplete. The descriptions (Schmidt, 1925a, and Pope, 1935) fit this specimen exactly. Its occurrence in western Hunan practically doubles the extent of its known range, which is given by Pope as Hainan, Yaoshan and northern Kwangtung.

Natrix stolata (Linnaeus).—A female of this species was taken near the airfield at Chihkiang September 20, 1944. Its scutellation is quite typical for the species as outlined by Pope. Upper labials 8, lower labials 9, preocular 1, postoculars 3, temporals 1 x 1, scale rows 19–19–17, ventrals 149, subcaudals 74. The total length is 311 mm. and tail length 75 mm. The current record extends the range of this snake well into the mountainous area of central China to the eastern edge of the Yunnan-Kweichow plateau.

Natrix tigrina lateralis (Berthold).—A female was taken from bushes bordering an irrigation ditch near the airfield at Chihkiang October 25, 1944. At this season it was by far the most common snake encountered in this area. It was seen frequently, always in the same type of habitat, where escape into deep brush-bordered water was possible. This snake has the following scale counts: upper labials 7, lower labials 10, preoculars 2, postoculars 4, temporals 1 x 2, scale rows 19–19–17, ventrals 148, subcaudals 55. Total length 774 mm., and tail length 143 mm. The coloration

is quite typical. The occurrence of this species in western Hunan, with previous records describing a 200 mile arc to the northeast, north and west, indicates that it has a wide distribution throughout central China, covering the Kweichow plateau and extending to the Yangtse River in the Tung Ting Lake area. It was taken at Chihkiang at an altitude of less than 3,000 feet, and was common at that altitude, though Pope suggests that at these latitudes one would expect it to be found at elevations approximating 6,000 feet.

Dinodon rufozonatum Cantor.—A female specimen was taken June 18, 1945, in a village near Linchuan, on the Honan-Anhwei border. It has the following scale counts: upper labials 8, lower labials 10, preoculars 1, postoculars 2, temporals 2 x 3, scale rows 19–17–15, ventrals 195, subcaudals 65. Total length 653 mm. and tail length 143 mm. The color in life was a glossy black with the crossbands bright red; the latter color faded to dull brown or dirty white in alcohol. I saw two juveniles that had been killed in this locality, and later this specimen was delivered by the natives who believed it to be deadly. This locality falls well within the known range of this widespread form.

Elaphe bimaculata Schmidt.—A female collected at Linchuan, May 31, 1945, does not agree in all characters with the published descriptions of *E. bimaculata* (Schmidt, 1925b, Pope 1935). The scale counts are as follows; upper labials 8, lower labials 11, preoculars 2, postoculars 2, temporals 2 x 3, scale rows 23–25–19, ventrals 197, subcaudals 61. Total length 790 mm., tail 112 mm. There are only 16 maxillary teeth. The dorso-lateral series of spots are separated completely by a whitish mid-dorsal stripe. The head pattern ends sharply on the occiput, followed by a space beyond which there are two more or less parallel spots on the neck, representing not more than two fused spots in the dorso-lateral series. This specimen agrees with the description of *E. bimaculata* in scutellation of the head, except for the lower labials, which number 11 instead of 9–10. In this character and also in the number of maxillary teeth it resembles *E. dione* rather than *E. bimaculata*, the typical number for the latter being 18–20, and the former 15–17. The specimen differs from typical *E. bimaculata* in the head pattern, which ends sharply at the occiput. In the pattern on the back the spots are completely separated, as opposed to the "dumbbell" shaped marks for *E. bimaculata*, and the narrow cross-bands of *E. dione*.

In connection with this specimen Boulenger's locality "Chen Lang Kwan, Gan King" (1894: 45) requires interpretation. Gan King is undoubtedly Anking, the capital of Anhwei Province, located on the Yangtse River near Wuhu. The native dialect of central China almost invariably pronounces the syllable "An" of the character meaning "peace," as "gan," or "ngan." Boulenger's "Gan King" then is a direct romanization of the local dialect. Chen Lang Kwan, on the other hand, is possibly a mistake for Chen Yang Kwan, a city at the junction of the Hwai and Sha rivers in northeastern Anhwei, now on the new course (1938–1946) of the Yellow River. This raises the question as to why two localities should be listed for a single specimen. My only suggestion is that Anking, the provincial

capital, is given to indicate the region in which the actual collecting site was located.

Identification of Chen Yang Kwan as a locality for *E. bimaculata* would extend the range as outlined by Pope northward from the lower Yangtse Valley approximately 150 miles. It is evident that the range does include this area as the snake described here was taken nearly 100 miles northwest of Chen Yang Kwan. A comparison of the British Museum specimen with the one at hand to see if it shows any trends towards the differences that are apparent in this individual might throw further light upon the correctness of the Chen Yang Kwan identity.

The possibility should not be overlooked that the specimen herein described may indicate an intergradation between *E. bimaculata* and *E. dione*, since the latter is a widespread form in east and north China whose range now partially overlaps that of *E. bimaculata* in the lower Yangtse Valley. A large series from the plains of northern Anhwei would be most interesting in this respect.

Bungarus multicinctus multicinctus Blyth.—A female specimen was taken near the airfield at Chihkiang October 24, 1944. It conforms exactly with Pope's description of 12 from Fukien. The scale counts are as follows: upper labials 7, lower labials 7, preoculars 1, postoculars 2, temporals 1 + 2, scale rows 15–15–15, ventrals 211, subcaudals 42. Total length 357 mm., tail 40 mm. There are 38 crossbands on the body and 13 on the tail. When captured this snake demonstrated the retiring manner so well described by Pope (1935:338). It threw itself into irregular coils and hid its head under its body. Nothing would induce it to strike. The present record extends the known range of the species up the Yuan River approximately 100 miles in western Hunan, closer to the high plateau that separates it from the subspecies *B. m. wanghotingi* to the west.

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Herpetological Notes

ACRIS IN MEXICO AND TRANS-PECOS TEXAS.—Current interest in the Big Bend region of Texas and adjacent parts of Mexico moves us to offer a few notes upon cricket-frogs from these areas.

The first published record of *Acris* in Mexico appears to be the listing, under *Acris gryllus*, of

"2 Mexico Dr. J. H. Garnier [Ex.] 12148-9"

in Sclater's "List of the Batrachia in the Indian Museum" (1892: 30). However, the specimens from La Lajita, Sabinas River, Rancho Golondrinas, near Muzquiz, Coahuila, tentatively referred to *Acris crepitans* by Schmidt and Owens (1944, Field Mus. Nat. Hist., Zool. Ser., 29: 100), provide the first definite Mexican locality for the genus. Several years ago Mr. Clifford H. Pope kindly permitted us to examine these specimens, an adult female (CNHM 28761) and ten barely transformed juveniles (CNHM 28762–71), collected by Ernest G. Marsh, Jr., in 1938. They are, unfortunately, in such a poor state of preservation that neither original dorsal pattern nor amount of wartiness can be distinguished. The single adult is noteworthy in having a very heavily marked throat, with the numerous brownish-black spots aligned into long chains. Unfortunately we have no female *crepitans* from extreme southern Texas for comparison (a male from Brownsville establishes the occurrence of cricket-frogs there), but the occasional females with spotted throats that occur from Michigan to Texas (possibly more frequently in Texas) never have such large nor such dark spots. The Sabinas River adult suggests that there is a north to south cline in females, culminating in heavily marked throats in the Coahuila population. The snout-to-vent length of the soft Sabinas River female is approximately 24 mm. This offers no evidence upon the possible continuance of the gradient toward greater snout-to-vent length from Michigan to Texas. Texas females frequently exceed 30 mm. in snout-to-vent length, and one at hand is 33 mm.

Wright and Wright (1938, Trans. Tex. Acad. Sci., 21: 22) give the range of *Acris gryllus crepitans* in Texas as, "Sabine River to trans-Pecos; Panhandle to southern Texas." This state-wide range is doubtless correct, but the form must be less common west of the 100th meridian, for the Carnegie Museum collection includes numerous specimens from east Texas localities, none from Trans-Pecos or the Llano Estacado, and only one from the Edwards Plateau (CM 5246, 10 miles south of San Angelo, Tom Green Co.). Furthermore, Schmidt and Smith (1944, Field Mus. Nat. Hist., Zool. Ser., 29: 77) omit *Acris* from their listing of amphibians known from the Big Bend region. We have been privileged to examine a series of seven Trans-Pecos specimens in the collection of the University of Michigan Museum of Zoology (UMMZ 84873), collected at Leon Spring, 8 miles west of Fort Stockton, Pecos County. These specimens, apparently the westernmost known *Acris*, differ markedly from east Texas material, which is in itself divergent from typical *crepitans*. [Decision as to the status of the east Texas population we prefer to leave to Dr. Francis Harper who is revising the genus.] The Leon Spring specimens are consistent in lacking any distinct dorsal pattern, and in having unusually warty dorsa, thighs with fewer well-developed warts, slender bodies and feet, and reduced webbing. They vary individually, however, in thigh pattern: four have pale, unbroken, ragged-edged postfemoral stripes; the remaining three have the stripes broken. The specimens are small, for they range in snout-to-vent length from 20—24 mm., average 22.5, whereas seven east Texas specimens, selected at random, range from 21.4—27, average, 24.8. The Leon Spring specimens appear to have longer legs than east Texas marteial, but this is probably due to their more slender bodies; actual measurements yield an average snout-to-vent divided by tibia ratio of 1.6 for both Trans-Pecos and Cis-Pecos specimens.—M. GRAHAM NETTING, *Carnegie Museum, Pittsburgh, Pennsylvania*, and COLEMAN J. GOIN, *University of Florida, Gainesville, Florida.*

A NEW LOCALITY FOR THE SPINY CHUCKWALLA, *SAUROMALUS HISPIDUS*.—That further exploration of the islands of the Gulf of California, Mexico would extend the ranges of some of the insular forms of *Sauromalus* was the writer's previously expressed opinion (1945, Trans. S. D. Soc. Nat. Hist., 10: 271). It was therefore not surprising to receive a specimen of *Sauromalus hispidus* Stejneger, collected by Mr. Bob Meanley on Nuevo Amor Island April 23, 1946, during the Lewis Walker expedition to Los Angeles Bay, Lower California. Nuevo Amor, a small island approximately 1 mile in diameter and about 300 feet in height at the highest point, is located about 2 miles off the east coast of the peninsula of Lower California, and is evidently one of the northernmost of a chain of 15 islands and islets described in H. O. No. 84, Sailing Directions for West Coasts of Mexico and Central America, 1937, as protecting the east and northeast approaches to Los Angeles Bay. The name Nuevo Amor does not appear on any of several maps of the Gulf of California which have been consulted but is applied to the island by the inhabitants of the village at Los Angeles Bay. The nearest locality from which *hispidus* has been previously recorded is Smith's Island some 4 miles to the northeast of Nuevo Amor. Two specimens were seen among the tumbled shale of Nuevo Amor and 1, an adult female 540 mm. in length, was captured beneath a slab of rock and returned alive to the San Diego Zoo. The specimen is a typical *hispidus*, displaying no appreciable differences in characters of scutellation from individuals collected on the other islands in the Gulf of California where this species is known to occur.

A question as to the origin of the *hispidus* inhabiting the smaller rocky islets in the vicinity of Angel de la Guarda seems to be presented in Van Denburgh's statement (1922, Occas. Papers Calif. Acad. Sci., 10, I: 101) "On Granite Island, a small rock near the north end of Angel de la Guardia Island, many dead chuckwallas were found strewn about the tops of the osprey's nests." That ospreys may have furnished a means of dispersal for *S. hispidus* does not seem to be a possibility too remote. Colonization of Nuevo Amor as well as Granite, Pond, Mejia, and perhaps even Smith's Island may have occurred in this manner. Mr. Walker informs me that ospreys were seen nesting on Nuevo Amor.

Mr. Walker also reports the introduction of *S. hispidus* to the peninsula of Lower California by human agency some time ago, one of the natives having brought two specimens from Angel de la Guarda Island, liberating them at the spring near the village at Los Angeles Bay. Neither of these individuals has since been observed, but there seems to be no reason to doubt the possibility of their establishment in favorable locations on the peninsula.—CHARLES E. SHAW, *Zoological Society of San Diego, San Diego 12, California.*

RESTRICTION OF THE TYPE LOCALITY OF *THAMNOPHIS SIRTALIS*.—Linnaeus (Syst. Nat., Ed. 10, 1: 222) gives "Canada" as the type locality of the common garter snake, *Thamnophis sirtalis* (Linnaeus). The collector of the type was Peter Kalm who traveled through the southern part of the Canadian province of Quebec during the summer and fall of 1749. While in the city of Quebec, Kalm observed and remarked upon harmless snakes. In "Peter Kalm's Travels in North America" (rev. & ed. Adolph B. Benson, New York, 1937: 471), the following passage appears: "I have been assured that there are no snakes in the woods and fields around Quebec whose bite is poisonous, so that one can safely walk in the grass. I have never found any that endeavored to bite and all were frightened." The diary entry is dated August 17, 1749. This indicates quite definitely that Kalm saw snakes in this area. Hence it is a logical assumption that some of these found their way into his collections and thence into the hands of Linnaeus. Furthermore, as at no other point in his account of his journey in Canada does Kalm mention snakes, and as Quebec lies well within the known range of the species, the probability that his specimen of *sirtalis* originated from the vicinity of Quebec is strengthened. In view of the foregoing it seems desirable to restrict the type locality of this species from "Canada" to the vicinity of Quebec.—ROBERT F. INGER, *University of Chicago, Chicago, Illinois.*

CONFIRMATION OF OVERWINTERING IN PAINTED TURTLE HATCHLINGS.—On June 18, 1944, Mrs. William H. Burt observed a painted turtle, *Chrysemys picta marginata*, laying eggs in an excavation about 50 yards from the edge of a swamp located in the eastern half of the southwestern quarter of Section 14, Lodi Township, Washtenaw County, Michigan. The next day I covered the nest site with a hardware-cloth tube similar to one previously described (COPEIA, 1944, 1:20-21).

In October, after carefully removing the nest plug, I observed three or four turtles fully hatched in the nest cavity, but saw no unhatched eggs. I replaced the plug and didn't disturb the nest again. Both Dr. and Mrs. Burt examined the tube at intervals during the late autumn of 1944 but found no signs of emerged hatchlings.

On March 18, 1945, the nest cover was still undisturbed but a week later, March 25, Dr. Burt found six hatchlings on the surface of the ground enclosed by the tube and one still in the now opened nest. Since there was no sign of undeveloped eggs the seven turtles represented a full complement.

When the turtles were brought to me on March 26 two were fairly clean but the others had large blobs of hard dry clay adhering to their carapaces. All seven still bore the egg tooth. They were washed, dried and then measured with the following results (measurements in millimeters, weight in grams):

Carapace length	Carapace width	Plastral length	Height	Weight
21.8	20.5	20.0	11.6	2.8
20.8	19.1	18.8	11.0	2.3
22 6	21.8	21.2	11.7	2.9
23.5	22.3	21.0	11.7	3.0
22.8	21.2	21.5	11.7	3.0
24.0	22.0	22.0	11.8	3.1
22.1	20.6	19.8	11.5	2.5

Characteristics present in these hatchlings but not normally found in adults from this area are the earth-red plastron (immaculate in one, with plastral blotch in six) and yellow stripes throughout the length of the head and neck. In adults the ground color of the plastron is yellow and the head and neck stripes are yellow anteriorly, red posteriorly.

On April 5, 1945, in the laboratory, they all showed vigorous, positive heliotropism. —NORMAN HARTWEG, *Museum of Zoology, University of Michigan, Ann Arbor, Michigan.*

NOTES ON BANDED WATER SNAKES FROM GEORGIA.—The study of thirteen specimens of the banded water snake from Clayton, Rabun County, Georgia, gave the following averages for various characters (figures in parentheses represent the range of variation): cross bands and dorsal spots 32.9 (31-35); anterior transverse bands 6.2 (4-9); ventrals 136.8 (131-142). In all the ground color of the dorsum was rather dark, the lateral interspaces were narrower than the lateral bars, and the venter was heavily mottled. This series fell within the range of variation of *Natrix sipedon sipedon* (Linnaeus), as defined by Clay (COPEIA, 1938). An approach toward *N. s. pleuralis* (Cope) was evident, particularly in the low ventral count.

Twenty-four specimens from Atlanta, Fulton County, gave the following figures: cross bands and dorsal spots 29.1 (26-33); anterior transverse bands 6.9 (3-14); ventrals 133.4 (130-139). The lateral interspaces were wider than the lateral bars in 10, and approximately equal in width to the lateral bars in the remainder. The ventral spots were in 2 rows in all but 6 of the series. Considered individually, 4 seemed closer to typical *sipedon*, 10 approximated *pleuralis*, and the remainder were intermediate.

Two hundred water snakes from Athens, Clarke County, yielded the following data: cross bands and dorsal spots 29.8 (25-36); anterior transverse bands 7.5 (4-15); ventrals 134.1 (127-139). The lateral interspaces were wider than the lateral bars in 170 specimens, while the ventral spots were in 2 rows in all. In most the dorsum was pinkish with dark red markings, the venter pale yellow maculated with red and black. The midventral area was frequently suffused with red or orange. The longest, a female, measured 1219 mm. The entire series was referable to *N. s. pleuralis*.

Natrix sipedon pleuralis was also taken at Lavender Mountain, Floyd County; Stone Mountain, DeKalb County; Attica, Jackson County; Lexington, Oglethorpe County; Crawfordville, Taliaferro County; and Uchee Creek, Columbia County.

The region about Augusta, Richmond County, has yielded 441 water snakes in a decade of collecting. Of these, 48 were *N. s. fasciata* (Linnaeus), 391 were *N. s. pleuralis*, and 2 could not be assigned to either race. The *pleuralis* were found on the northwestern or Piedmont side of Augusta, *fasciata* on the southeastern or Atlantic Coastal Plain side. Their respective ranges are adjacent, with no evidence of overlapping. The characters of the *pleuralis* averaged as follows: cross bands and dorsal spots 30 (26-34); anterior transverse bands 7.8 (3-12); ventrals 133.3 (128-138). The ventral spots were semilunar and in 2 rows in all. The *fasciata* gave these figures: transverse bands 27.8 (26-31); ventrals 129.5 (127-133). All were marked ventrally with subquadrate spots. A distinct postocular dark stripe was present in 37. The intermediate specimens were both taken in localities inhabited by *fasciata*, but resembled this race only in being marked with transverse bands. In areas where the transition from one physiographic region to another is less abrupt, intergradation may be more pronounced.

Natrix sipedon fasciata was also collected at McBean, Richmond County; Midville and Waynesboro, Burke County; Louisville, Jefferson County; Millen, Jenkins County; Sylvania, Screven County; Alma, Bacon County; Statesboro, Bulloch County; and Savannah, Chatham County.

Wright and Bishop (1915, Proc. Acad, Sci. Phila.: 175) noted that the banded water snakes of Okefinokee swamp of Georgia resembled *N. s. pictiventris* (Cope). This record received little attention from later workers, probably because of the widespread occurrence of supposed *fasciata* in northern Florida. Recently, Carr (1940, Univ. Fla. Pub., 3: 87) has indicated that these do not represent true *fasciata*, but result from fortuitous genetic combinations in populations of *pictiventris*. Three water snakes, taken by the writer at Chesser's Prairie, Ware County, were indistinguishable from the *pictiventris* of peninsular Florida. The ground color of the dorsum was a rich orange, with 30 to 34 black transverse bands. The ventrals, 121 to 126 in number, were bordered anteriorly and laterally with red, leaving light midventral areas. A specimen from St. George, Charlton County, showed the following characters: transverse bands 29; ventrals 128; two-thirds of venter with dark anterior borders to the scutes and posterior third of venter with subquadrate red spots. These data indicate an intergrade between *fasciata* and *pictiventris*.

It appears that typical *sipedon* enters the state only in the mountainous northeastern corner, intergrading with *pleuralis* in the upper Piedmont. The latter form ranges thence to the Fall Line, and into the Appalachian Valley. Typical *fasciata* is generally distributed throughout the Coastal Plain, except in the Okefinokee region, where it is replaced by *pictiventris*.

The related species, *N. erythrogaster erythrogaster* (Forster), was collected at every locality listed for *fasciata*, and was also found in the Piedmont at Crawfordville, Athens, and Atlanta.—WILFRED T. NEILL, *Department of Biology, Richmond Academy, Augusta, Georgia.*

NOTES ON THE HERPETOLOGY OF ELMORE COUNTY, IDAHO.—While stationed for an eight month period with the Army Air Forces at Mountain Home, Idaho, I had the opportunity to study the herpetology of various parts of Elmore County, north and south of Mountain Home, from the Snake River in the south to the higher mountains in the north. Mountain Home is about 50 miles southeast of Boise, Idaho, on U. S. Highway 30.

This area is more or less a rolling plateau, with many rocky outcroppings, with an average elevation of about 3000 feet. There is very little tree growth, the primary vegetation being sagebrush, with scrub willows along the temporary stream courses.

Notes on the various species follow:

Scaphiopus hammondii intermontanus Cope.—On May 11, 1944, about one hour after a very heavy downpour in the late afternoon, we came upon a few specimens above ground in an orchard at the edge of town. This was our only record.

Bufo woodhousii Girard.—In the Snake River Canyon we found a pair of Rocky Mountain toads at a small pool just off the edge of the river (June 17, 1944) in the act of copulation; the male was approximately 4 inches, and the female about 5¼ inches in body length.

Pseudacris nigrita triseriata (Wied).—While waiting for transportation to the air base I heard the evening chorus of these frogs on April 6, 1944. Checking the next day I found a ditch beside the railroad tracks well-stocked with this species. No egg masses were found, but by October 14, 1944, there were swarms of adults, as well as tadpoles in the transformation stage, in the same ditch.

Hyla regilla Baird and Girard.—On April 7, 1944, my wife and I found 2 Pacific tree frogs in a swampy area of Camas Creek, at an elevation of about 4300 feet, in the mountains about 20 miles northeast of Mountain Home. Both alders and willows were present in this area. One male had a nearly black throat.

Rana pipiens Schreber.—We found an adult leopard frog, and thousands of tadpoles probably of this species, in a swampy area, fed by springs, on June 17, 1944. The water was clear and quite cool. This area was at the bottom of the Snake River Canyon, not far from the river, and about 15 miles southwest of Mountain Home.

Crotaphytus collaris baileyi (Stejneger).—A single female, about 10 inches long, from the rocky outcrops on the very rim of the Snake River Canyon, some 15 miles southwest of Mountain Home. This species seems quite rare in this area.

Crotaphytus wislizenii Baird and Girard.—First seen on May 28, 1944, near a reservoir northeast of Mountain Home, the leopard lizards later proved to be more abundant in the area south of Mountain Home, toward the Snake River. They were common over most of the plateau, but were never right down in the river canyon, nor in a strip for a mile or so north of the rim of the canyon, as were some other species. On June 17, 1944, one in the breeding coloration of the female was seen. It was fully 16 inches long, with a deep, thick body, and with the head, shoulders, and sides spotted with red. The last specimen of this species was seen on September 2, 1944.

Uta stansburiana stansburiana (Baird and Girard).—This lizard is one of the first species active in the spring. We saw our first ones on May 7, 1944, northeast of Mountain Home. Specimens were found in the bottom of the Snake River Canyon as well as on the plateau. Small ones not over 2 inches in length were seen on September 2, 1944. The largest seen measured about 5 inches.

Sceloporus graciosus graciosus (Baird and Girard).—On September 2, 1944, I saw a specimen of this species, the only one identified in this area.

Phrynosoma douglassii douglassii (Bell).—A pigmy horned lizard was caught on the rifle range, near the airbase, in the late afternoon of April 22, 1944. Temperatures for that day, and the preceding days, had not been over 65°F.

Phrynosoma platyrhinos Girard.—Many taken from June 7 to September 2, 1944. The largest were from 5 to 6 inches long. Juveniles from 1¼ to 1¾ inches in length were common in September. Specimens from the area south and southwest of Mountain Home had backs strongly rusty colored.

Cnemidophorus tessellatus tessellatus (Say).—Desert whip-tailed lizards were seen on trips to the Snake River Canyon on June 7, and 17, 1944. They were on the rim and plateau near the river, but not very far from the canyon rim, more or less complementing the range of the leopard lizard. On June 17 there was a heavy concentration of them along the sandy banks of the river, and back from the river, in the canyon, for the entire distance that we hiked along its banks. They were exceedingly noisy in the underbrush. None were seen during the late summer and early fall in this same area.

Pituophis catenifer deserticola Stejneger.—A desert gopher snake, about 30 inches long, was found near the reservoir northeast of Mountain Home on April 27, 1944. On June 7, 1944, another was found, about 12 miles to the southwest, curled up under a clump of sagebrush.

Crotalus viridis lutosus Klauber.—On June 7, 1944, we encountered a rattlesnake of this species approximately 40 inches long, very inactive early in the day.—Fred G. Evenden, Jr., *Oregon State College, Corvallis, Oregon.*

AN ALBINISTIC SPECIMEN OF *PSEUDACRIS FERIARUM*.—During the course of field work in northern Virginia, the senior writer collected an albinistic *Pseudacris*, which is tentatively referred to *P. feriarum* (Baird), the common Virginia species. Records of albinism in amphibians are few, and this is believed to be the first notice of this mutation in *feriarum*. The specimen was collected about 5 miles northwest of Winchester, Frederick County, on the afternoon of August 25, 1945, in short grass near

a woodpile. The nearest permanent water was about a quarter of a mile distant, but temporary ponds existed nearby for some time during the spring. The specimen is an adult male, apparently normal in every respect except for the lack of pigmentation. There is a slight amount of stippling on the head, enough to define the characteristic white labial stripe of the species.

Cahn (1926, COPEIA, 151: 62) discussed the discovery and development of a pair of albino egg masses of *Pseudacris n. triseriata*. The larvae hatched therefrom were pure white, the first chromatophores appearing on the second day following transformation. None of the larvae were allowed to live to transformation. Cahn stated: "That the parents were not albinos goes without saying. . ." It does not seem unlikely to us that one or both of the parents might have been albinistic, for our specimen shows that such individuals can attain maturity. Instances of albinism in adult *Rana* are known.

Efforts to collect other albino *Pseudacris* in the same area have been unsuccessful.—JOSEPH F. ACKROYD and RICHARD L. HOFFMAN, *Winchester* and *Clifton Forge, Virginia.*

AN UNUSUAL HABITAT FOR FROGS AND LIZARDS.—Widespread on the islands of the Pacific region are the so-called ant-plants (*Hydnophytum* and related forms). These plants are apparently the sole habitat of many species of ants, and the frequent abode of others. Some authors have suggested that the relationship involved is a symbiotic one, the insects disseminating the seeds of the plant that affords them shelter. These floral oddities grow epiphytically upon the branches of trees, often at considerable distances above the ground. The plant consists of a globular mass of water-storing tissue, sometimes a foot or more in diameter, from which arise the leaves and anchoring roots. The central mass is honeycombed with passages, some of which open on the under side of the plant. This labyrinth usually swarms with ants, which violently resist any invasion of their domicile.

Ant-plants were abundant on the outskirts of Waigani Swamp, an extensive marshy tract about 7 miles north of Port Moresby, Papua. On August 15, 1943, I investigated a particularly large one. Halving it with a machete, I was surprised to see several frogs hopping away. Upon collection, these proved to be *Hyla mcgregori*, a common form in the Moresby area. Careful examination of the plant—at the expense of numerous stings from the hordes of ants that infested it—revealed 23 frogs of this species, nestled within the cavities. Thereafter I dissected every accessible myrmecophyte, often finding a dozen or more of these frogs in a single plant. On October 12, 1943, one of the cavities yielded 11 small, white eggs. These, when broken open, revealed fully developed young of the scincid lizard *Cryptoblepharus boutoni*. Several females of this species had been previously observed to deposit only 2 eggs. This, together with the fact that the young were apparently of the same age, suggests that there had been an unusual congregation for oviposition. A few days later, another clutch, containing 4 eggs, was discovered. One adult *Cryptoblepharus* in the same habitat escaped before I could seize it.

Neither species is particularly dependent upon the ant-plant. *H. mcgregori* is found during the day beneath loosened slabs of bark or in thick leafy clusters of vegetation. At night it hops about in low bushes or on the ground, often making its way far out into the grasslands. During prolonged dry spells, however, the species is seldom found outside the myrmecophyte. *C. boutoni* occupies a wide variety of habitats, ranging from swamps and forests to grassland and sea beaches. Its eggs were several times discovered in debris at the bases of rotting trees. Various other arboreal hylids, scincids, and gekkonids were taken about Waigani Swamp, but none of these was ever found in an ant-plant.

The situation calls to mind the widespread occurrence of reptiles and amphibians in the bromelias of the American tropics, and suggests that water-retaining plants may provide fertile collecting grounds in other regions of the world.—WILFRED T. NEILL, *Department of Biology, Richmond Academy, Augusta, Georgia.*

Ichthyological Notes

ON YOUNG WESTERN ATLANTIC SERIOLAS.—Species of the genus *Seriola* in the western Atlantic are in need of revision. With the exception of the banded rudderfish, *Seriola zonata* (Mitchill), type locality New York, about which there can be no question, the nomenclature of the best known forms is uncertain. How many are recognizable, and to what extent they are identical with those of the eastern Atlantic is a matter of opinion. The banded young of this genus are common in collections, but often difficult to identify and it will be helpful to describe the two kinds of which the writer has adequate knowledge and material at hand.

Seriola zonata (Mitchill)

The number of rays in the dorsal fin varies considerably in *Seriola*, much more than in the somewhat shorter anal. The only tangible differences which *Seriola zonata* shows from the great amberjack of Florida are a larger number of dorsal soft rays (36 to 40 versus 31 to 34), and that it does not attain so great a size. In the vicinity of New York, although 38 to 40 is the rule, individuals with only 34 rays are not rare among the larger fish. We have a specimen of 173 mm. from Long Island and one of 210 mm. from New Jersey (standard lengths) with that number. Presumably fish of over 150 mm. range widely north and south along the coast, as they would be quite capable of doing. Similarly we have a 200 mm. specimen from Cape Lookout, North Carolina (collected by Russell J. Coles), with 38 rays, but in 8 young of 35 to 60 mm. from there, 5 have 34, 2 have 33, 1 has 32; and 3 specimens of 30 to 33 mm. from Key West have about 31 soft dorsal rays. From evidence at hand *Seriola zonata* is apparently at best no more than a cooler-water race of the great amberjack at the northern edge of its range. The great amberjack has recently been identified with *Seriola dumerili* (Risso) of the Mediterranean, perhaps correctly so, but the writer is not convinced of the validity of this, and prefers to follow an earlier usage and identify it with *Seriola lalandi* Cuvier and Valenciennes, type locality Brazil. As *zonata* has priority over *lalandi*, the latter would be a race of the former, and *S. zonata* the common comprehensive Atlantic coast *species* from Cape Cod to Florida.

Its banded young have a consistent color pattern shown by specimens examined of 30 to 93 mm. standard length from New York, North Carolina and Florida. There are 6 broad, regular black cross bands, the sixth on the front of the peduncle just behind the dorsal and anal axils. These bands are continued on the vertical fins, most conspicuously so on the second dorsal, which hence is alternately light and dark. A slanting nuchal band is no darker than the crossbands, and least pronounced at its upper end. There is some tendency to a dark shade within the arc made by the bases of the caudal rays, not across between the corners of the arc as in *falcata*. At larger sizes the crossbands fade and disappear, the sixth being the first to be lost.

Seriola falcata Cuvier and Valenciennes

The fish known as bonito at Bermuda, where it is common, stands as *Seriola* (*Zonichthys*) *falcata* Cuvier and Valenciennes, type locality Gulf of Mexico (*Zonichthys falcatus*, Beebe and Tee-Van, *Fishes of Bermuda*, 1933: 111), but its identification therewith is not too satisfactory. Furthermore it may be identical with *S. rivoliana* Cuvier and Valenciennes of the Mediterranean. Eastern Atlantic *Caranx guara* and *Syngnathus pelagicus*, for instance, are common at Bermuda, rare in Florida and the West Indies. It differs from *S. zonata* in having a deep head and body, higher vertical fins with falcate lobes, fewer dorsal soft rays (25 to 32), and longer and more numerous gill-rakers (15 to 19 versus 10 to 15 on the lower limb of the first arch). Among young Carangidae from Bermuda in the New York Zoological Society's collections, kindly loaned the writer for study by Dr. William Beebe, there are 23 small seriolas of 17 to 57 mm. standard length, all identifiable as of this species on the basis of fin-rays and gill-rakers. A specimen of 37 mm. from Cape Lookout, North Carolina, and 3 of 31 to 43 mm. from the east coast of Florida (collected among gulf weed by A. H. Schmidt) are obviously the same thing.

In specimens of this species examined (5), from 17 to 22 mm. standard length, there are 5 definite dark crossbands on the body. These are somewhat irregular in width, the 3rd and 4th tending to be broadest. There is also a tendency for a sixth cross mark at the base of the caudal. This is not counted as a crossband in this discussion. From 23 mm. upward, one or more of the crossbands have darker edges or are more or less split by paler centers. This is most pronounced in the broader bands. This tendency increases with size until one or more bands become well separated into two relatively narrow ones. The two sides are not necessarily alike in pattern. Thus in 9 specimens ranging from 23 to 30 mm., one of 24 and one of 29 mm. have 6 crossbands on the right, 5 on the left side; one of 28 mm. has 6 on the right, 7 on the left; 6 from 23 to 30 mm. still have 5 on both sides. In 13 specimens of 31 to 57 mm., 2 of 31 mm. and one of 53 mm. both sides have 5; one of 34, one of 44, and one of 51 mm., both sides have 6; one of 37 has 5 on the right, 6 on the left side; 4 of 31, 39, 43, and 57, have 6 on the right, 5 on the left; 2 of 33 and 46, have 5 on the right, 7 on the left side. In specimens of 17 to 22 mm. standard length there are 5 bands on a side; in those of 23 to 30 mm. there is an average 5.3 bands to a side; in those of 31 to 57 mm. the average is 5.6. The crossbands are not continued on the vertical fins, which are rather uniformly darker or paler. The nuchal band tends to be darker than the crossbands and reaches the front of the spinous dorsal, crossing the first crossband.

The young of *S. falcata* are frequently distinguishable from those of *S. zonata* by a more elevated profile or back. They tend to be shorter bodied, and to have shorter, paler ventrals. The ventrals in *S. falcata* are sometimes quite pale on the outer side and blackish on the inner side as contrasted with black on both sides in *S. zonata;* but these differences are masked by individual variation, leaving the number of gill-rakers and pattern of crossbands as reliable criteria.

There is some indication of variation in number of dorsal soft rays with water temperatures in young *S. falcata* though this is in nowise comparable with the condition in *S. zonata.* In the 23 Bermuda specimens nine have 28, seven have 29, four have 30, and there is one each with 26, 27, and 31 (average 28.6); the 3 specimens from the east coast of Florida have 25, 29 and 30 (average 28); the one from North Carolina has 32 rays.—J. T. NICHOLS, *American Museum of Natural History, New York.*

ON TAXONOMIC QUESTIONS RELATED TO THE CLASSIFICATION OF *BARBOURISIA,* THE CETOMIMIDAE AND THE INIOMI.—In COPEIA, 1946 (No. 1: 41–42), it is proposed by Myers that the genus *Barbourisia* Parr, 1945, be placed in a separate subfamily within the Cetomimidae, rather than having an entirely separate family maintained for this peculiar genus, as proposed by myself (COPEIA, 1945, 3: 127–129). The particular point at issue is, of course, a very minor one, but the discussion raises many questions of considerable interest and rather wide implications.

Myers quite properly questions the *general* taxonomic significance of the presence or absence of pelvic fins, particularly in an abdominal position. I fully share his doubts on a *general* basis, and I am not very satisfied about the particular case involved. Yet it is also a textbook commonplace in botany, zoology and perhaps particularly in paleontology that features which may be subject to extreme individual variations within a single species in some groups, may be of high systematic significance and phylogenetic rigidity even in very similar and closely related forms. Specific or even individual variations in the presence or absence of pelvic fins in the various familes mentioned by Myers, are, of course, well known. But none of these groups are in any close systematic proximity to the Iniomi which are under discussion. There is also another factor to be considered and that is the presence or absence of intermediate forms among the species or genera compared. Among the Blenniidae *sensu lato,* for instance, one may find all stages from absence of pelvic fins, through a single, sometimes rudimentary ray to fully developed fins. In the four genera of the Cetomimidae, on the one hand, we find a complete and universal absence of pelvic fins. In *Barbourisia,* on the other hand, we observe entirely normal pelvic fins with six rays.[1] There are as yet no intermediate stages known

[1] The writer wishes to take this occasion to correct a misprint in the description of *Barbourisia rufa.* For "PBV6" (COPEIA, 1945: 128) read: P 13, V 6.

among these forms. The justification of Myers reference to Breder's demonstration of the relative uselessness of the pelvic fins in active swimming is also open to doubt in dealing with mechanically inefficient forms leading a bathypelagic existence. Such species have no means of resting except by gliding, using this term in the widest sense to include the use of any morphological feature adapted to retard sinking, except the use of buoyancy adjustments by chemical processes. As I have pointed out elsewhere (Bull. Bingham Oceanogr. Coll., III, Art. 7, 1937: 32) the functioning of a swimbladder under bathypelagic pressure conditions would, for thermodynamic and mechanical reasons, be so highly inefficient in regard to energy expenditure that it is very questionable whether a bladder can be used in these circumstances even when it is still morphologically present as a product of earlier evolution. In any event it makes it extremely desirable for a bathypelagic species to seek physiologically less expensive means of attaining suspension at rest.

The question of the theoretical systematic significance of the presence of pelvic fins in the particular species under discussion must therefore, at least to me, remain an entirely open one. They cannot be shown to be theoretically important, nor has it been shown that they are not. In the meantime the practical fact remains, that in the complete absence of intermediate forms, the presence of pelvic fins in *Barbourisia* offers a very convenient means of tracking the species down through the hierarchy of taxonomic ranks, beginning at the family level. And the feature does not stand alone as a distinguishing mark, but is coupled with others.

Myers also minimizes the importance of the densely spinulose skin of *Barbourisia* as compared with the entirely smooth skin of the four genera of the Cetomimidae, but neglects to offer any analogy or suggestion to show how this condition of the skin can reasonably be derived from the characteristics of any other form previously included in the entire order Iniomi, let alone the family Cetomimidae. Again we have a case of complete absence of intermediate phases. But of much greater importance is the fact that a spinulose skin is a natural evolutionary derivation of a ctenoid squamation, but can scarcely be imagined as a derivative of the cycloid scales of the Iniomi. The skin of *Barbourisia* is strongly reminiscent of that of various deepsea Berycomorphi, *sensu lato*, among which a transition from small ctenoid scales to spinulose skin can still be traced, although this, probably very heterogeneous, order is also made to include many forms with cycloid scales.

There is also the question of color. This is of course generally considered of very slight taxonomic significance, and rightly so. Among shallow water fishes, especially those in a colorful environment such as coral reefs, every color of the spectrum may be present, subject to individual variation and even to temporary variations on the same individual. Nevertheless certain general rules of rather broad systematic validity seem to apply to the forms which enter a pelagic, and particularly a bathypelagic, existence. Among the bathypelagic representatives of the orders Isospondyli, Iniomi (except *Barbourisia*) and Anacanthini, and of other groups, we find only black (dark), *silvery* or transparent forms. Among the Xenoberyces, Percoidea, Brotulidae, Pediculati and other groups, only black, *red*, or transparent species inhabit the depths. It would almost seem as though silvery, and what may be called deepsea-red, are mutually exclusive within any well defined group with clearly established internal relationships. Biology has barely begun the study of the taxonomic significance of body chemistry, but enough has already been found to show the profound phylogenetic importance of biochemical distinctions. Perhaps the relationship between silvery and deepsea-red may ultimately prove a case in point. Another red percoid would be no surprise, but the possibility of having to count with a deepsea-red member of the Iniomi seems as startling to this student of deepsea fishes as it would be to encounter a silvery ceratioid or a good red herring.

In view of these considerations I am not entirely inclined to agree with Myers that there is nothing to show that the Barbourisiidae is not very closely related to the Cetomimidae unless perhaps Prof. Myers would also agree that there is likewise nothing to show that they are closely related. For this last point one may see support in some of Myers' own comments. The features which caused the earlier writers to place the Rondeletiidae (now in the Xenoberyces, see Parr, 1929, Occas. Pap. Bingham Oceanogr. Coll. No. 2) among the Iniomi, near, or in, the Cetomimidae, are characterized by Myers as superficial similarities, and justly so. Nevertheless the known dissimilarities between the Bar-

bourisiidae and the Cetomimidae are far greater than those which were known to exist between the latter and the only "superficially rather similar" Rondeletiidae before an anatomical study of *Rondeletia* became possible.

Barbourisia differs from all cetomimids, 1) by the presence of normal pelvic fins as compared with their complete absence; 2) by a densely spinulose skin as compared with a completely smooth and scaleless skin; 3) by a red color in life and complete absence of melanic elements in the color of the skin, as compared with a completely melanotic pigmentation; and by other features. *Rondeletia* apparently differed from the Cetomimidae chiefly by the possession of pelvic fins alone, but entirely agreed with the cetomimids in regard to the other characters here considered of significance, and shows no other differences not shared or matched by *Barbourisia*. The same standards of significance must be used in weighing all sides of a question.

In regard to body form and general appearance the Cetomimidae contain two strikingly different types of fishes, which again seem to present a distinction without intermediates. On one hand we have the depressed tadpole-like *Gyrinomimus*, on the other the more or less compressed members of *Ditropichthys*, *Cetomimus* and *Cetostomus*, with their somewhat whale-like profiles. In my description of the Barbourisiidae I stated that the general shape of head and body, and the form and arrangement of the vertical fins are as found in *Cetostomus*. Myers asserts that *Barbourisia* is very similar in general form to *Gyrinomimus*, but since this statement is made without examination of the specimen, the contradiction it creates is probably the result of haste rather than intent. Of all the genera of the Cetomimidae the genus *Gyrinomimus* is the one which least resembles *Barbourisia* on all counts, both as to general form, the number of gills, the absence of gillrakers, and so on.

Myers continues to refer to the "problematical *Pelecinomimus*" although one had hoped that this genus had been effectively cancelled by J. L. B. Smith's correction of the original description, and his transfer of the genotype to *Cetomimus*, as pointed out in my account of the Barbourisiidae which started this discussion. It would be interesting to know the reasons for this revival of a genus or at least a generic term which seemed well buried.

In my discussion of the Barbourisiidae I expressed a suspicion that the family Cetomimidae "may only represent a very artificial assemblage" and that "other members" than the erstwhile member *Rondeletia* may ultimately have to be placed elsewhere. This is considerably different from saying that the Cetomimidae, as such, may prove to belong to another order than the Iniomi, as implied by Myers' interpretation of my remarks. In the only cetomimid which it has yet been possible to study anatomically (*Cetostomus regani*, see Parr, 1929, *op. cit.*) I found no evidence to compel a removal from the Iniomi. But I continue to feel unsatisfied concerning the true relationships of *Ditropichthys*, in particular, and also to a considerable extent in regard to *Gyrinomimus*.—A. E. Parr, *American Museum of Natural History, New York 24, New York.*

THE PROBABLE IDENTITY OF *NEACANTHOPSIS GRACILENTUS* H. M. SMITH.—In the extensive work on the freshwater fishes of Siam (Bull. U. S. Nat. Mus., clxxxciii, 1945) by Hugh M. Smith, published posthumously, there appears on page 297 an account of a supposed new genus and species of loach (Cobitidae). I am unable to find, however, in the description and figure given, any significant character by which this fish, *Neacanthopsis gracilentus*, can be distinguished from the common and widely distributed *Cobitis taenia*, and am of the opinion they will prove to be identical.

Cobitis taenia ranges across Europe and Asia from Britain to Japan, and exhibits a number of local or individual variations. The Siamese examples show a colour-pattern very similar to some Japanese specimens. Smith is to be forgiven for not expecting to find this Palearctic species so far south, but it is interesting to note that his specimens were collected in the upper reaches of the Meping River, in the high country of northern Thailand. From this it seems not unlikely that it will be found to inhabit cool mountain streams along the whole eastern edge of the Tibetan plateau, and has thus extended its range southward along this line.—A. Fraser-Brunner, *Department of Zoology, British Museum (Natural History), London, S.W. 7, England.*

AN INTERESTING ASSOCIATION OF FISHES.—During the progress of some fish rescue work carried out near Barbour's Hill, Chambers County, Texas, by the Texas Game, Fish and Oyster Commission, a most unusual association of fishes was observed. The rescue work was carried out in the residual pools of a recently drained rice canal and, during the time I was with the crew, only two pools were seined. These lay within a half-mile of each other. The seine used undoubtedly let many of the smaller fishes escape. I feel sure that both *Gambusia affinis* and a species of *Fundulus* probably occur in the canal, although we obtained none. We did obtain twenty-three other species. They were:

Ameiurus sp.
Aphredoderus sayanus
Achirus fasciatus
Aplodinotus grunniens
Cynoscion sp.
Cyprinus carpio
Chaenobryttus coronarius
Dormitator maculatus
Dorosoma cepedianum
Elops saurus
Huro salmoides
Ictiobus bubalus
Ictalurus furcatus
I. punctatus
Lepisosteus osseus leptorhynchus
L. platostomus
L. spatula
Lepomis cyanellus
L. macrochirus
Mugil cephalus
Micropogon undulatus
Morone interrupta
Pomoxis nigro-maculatus

In addition we collected numerous blue crabs, *Callinectes sapidus*, two large specimens of Troost's turtle (*Pseudemys scripta troostii*), and a diamond-backed water snake (*Natrix rhombifera rhombifera*). These snakes were quite numerous and fed boldly on fish that spilled out of the seine.

The most numerous fish was *Dorosoma cepedianum*, the numbers of this species probably exceeding that of all the others combined. Second in abundance were the centrarchids, *Lepomis cyanellus* being the most numerous of the family. *Aplodinotus grunniens* was quite plentiful, as were two of three catfishes, *Ictalurus furcatus* and *I. punctatus*. Only a single *Ameiurus* was taken. All the lepisosteids were less than 2 feet in length, and only three specimens of *Lepisosteus spatula* were taken. The most plentiful species of this family was *L. platostomus*, with *L. osseus leptorhynchus* only slightly less numerous. There were only four specimens of *Morone*, five of *Dormitator* and one of *Aphredoderus* in the entire catch.

The marine species, present in water which was apparently fresh, were by far the most interesting portion of the catch. Gunter (1942, Amer. Mid. Nat., 28, No. 2), in his paper on euryhalin fishes, notes that *Micropogon* and *Cynoscion nebulosus* have both been found in fresh water in Florida, while in his 1938 paper (COPEIA: 69-72) he has recorded the occurrence of *Achirus fasciatus* in the waters of the Mississippi-Atchafalaya river system. *Elops* is known to ascend the Colorado and enter the Salton Sea, while *Mugil cephalus* has been found in the Navasota River of Texas, 200 miles from the Gulf. However, I have been unable to find any notice of such a congregation of marine fishes as I have mentioned here occurring in comparatively fresh water, and certainly no such combination of marine and freshwater species.

This collecting spot in the canal was approximately 35 miles from its intake, the canal water being pumped from what is known as Old River, a cutoff of the Trinity, connected to Galveston Bay at its mouth. There seems little reason to doubt that the marine species were drawn through the pumps at an early stage in their development and remained in the canal during their period of growth. No test of the salinity was made, but an official of the canal company informed me that once during the summer the water contained 17 grains of salt per gallon. Ordinarily the salt content is much less.—J. L. BAUGHMAN, *Texas Game, Fish and Oyster Commission, Rockport, Texas.*

Reviews and Comments

HANDBOOK OF LIZARDS. By Hobart M. Smith. Comstock Publishing Co., Inc., Ithaca, New York. XXI + 557 pp. Illus. $5.75.—Someone has said that an Asiatic reptile or amphibian is more readily identified than a North American one. Smith's new handbook appreciably weakens this statement, which has been a shameful admission for American herpetologists. It is the very fact that more work is done on the American fauna than on any other that makes the writing of comprehensive works extremely difficult. The present work is more monograph than layman's account; it will be used chiefly by professional herpetologists and other zoologists. The layman will find its wealth of detail confusing. However, the numerous illustrations will enable him to use the book to some extent. The index, in spite of being long, does not give "Gila monster," "Horned toad," or "Glass-snake" under any of the five initial letters. These and other similar omissions will puzzle the lay reader. It is astonishing in contrast to find "Hoopsnake" listed in the index.

The book begins with an excellent 59-page introduction to lizard biology, with emphasis on our native species. Such important subjects as Distribution, Fossil History, Structure, Habitat, Life History, Habits, Economic Importance, Collecting, and Preserving are taken up in sufficient detail. A full glossary of descriptive terms is also included. A section on American Saurologists has photographs of twelve authorities but unfortunately omits the likeness that should have preceded them all—that of the author.

The 422 pages that follow the introduction take up one after another of the 127 forms known to occur in our 48 states. Nine other forms are also treated: 4 introductions, 1 that was probably introduced, 4 that range suspiciously near our borders. Among the nine families represented in the indigenous fauna, only the Iguanidae are found in profusion: 77 forms grouped into 14 genera. Next in abundance are the Scincidae with 21 species and subspecies but only 3 genera. There is an astonishing agreement in numbers between the salamanders, as described by Bishop's "Handbook of Salamanders," and the lizards:

	Families	Genera	Species	Forms
Lizards	9	26	82	127
Salamanders	7	25	87	124

It is further interesting that these faunas supplement each other, the lizards being more numerous where the salamanders are all but unknown, and vice versa.

The account of every form is detailed and places as much emphasis on habits and life history as on description. Each account begins with a statement of the range, this statement supplemented by a map for every form except two introduced ones. All of the 41 maps are grouped together and follow the account by species. The statement of range is followed by descriptive sections headed Size, Color, Scalation, and Recognition Characters. The last of these, by far the most useful, will save the reader hours of toil in making identifications, and is further evidence of the prodigious care and effort that has gone into the writing of this book. The curse of herpetological literature is long, unorganized descriptive matter.

Information on behavior and adaptation is treated under Habits. Smith has covered the literature with characteristic thoroughness, often devoting more than a page to a single form. This part will have such wide appeal that additional subheads would be helpful. For instance, the reproductive behavior might well have had its own heading. Habitats are discussed in ample detail in separate paragraphs.

The two final sections deal with problems and literature. Both of these are extremely valuable parts of the species treatment. Documentation is thorough, with eight pages of bibliography, literature given for each form, and important references after the 44 state lists (Maine, New Hampshire, Rhode Island, and Vermont have no lizards). The eight pages of straight bibliography are needlessly divided in two parts, one headed General Literature preceding the state lists, the other headed Literature Cited and

following that list. The plan of giving references after each state list is commendable but does not preclude the necessity of having one complete bibliography.

The author has spared no pains in illustrating this book. The plates number 135, the text-figures 136. Only two among 136 forms are not shown, and these do not warrant illustration, one being an introduction, the other a species of doubtful occurence within our boundaries. Pictures are dispersed through many of the keys, greatly facilitating their use. A few photographs of habitats, nests or lizards in action would have relieved the monotony of hundreds of sterotyped pictures showing external structure only. The background of many plates is marred by unnecessary lines and differences in shade. This defect and the poor half-tone reproduction must be blamed on the publisher, who no doubt may justifiably pass the blame on to our bad times.

Errors are few. As a former resident of New Jersey I cannot refrain from stating that *Sceloporus undulatus hyacinthinus* does not range northward throughout New Jersey and into southeastern New York but is confined to the pine barrens of the southern half of the state; New York records are based on an isolated colony. Further, on the map this lizard's name is given as *S. u. fasciatus*, in the text as *S. u. hyacinthinus*.

Pointing out such minor inaccuracies is scarcely justified in view of the magnitude and excellence of this landmark in the study of our reptiles. With this firm foundation as a fulcrum, herpetologists may now proceed to the final stage in taxonomic investigation. Research in life histories is far behind but it too should receive fresh impetus from this same source.—CLIFFORD H. POPE, *Chicago Natural History Museum, Chicago, Illinois.*

ELEMENTARY STATISTICS AND APPLICATIONS. By James G. Smith and Acheson J. Duncan. McGraw-Hill Book Company, Inc., New York. X + 720. $4.50.—This text covers the usual topics of elementary descriptive statistics. The applications, however, are more appropriate for economists rather than biologists. Fishery biologists, who are interested in index numbers, cycles, and trend analysis, will find Part V, The Study of Dynamic Variability, quite useful.—C. M. MOTTLEY, *Fish and Wildlife Service, Washington, D. C.*

NORTH AMERICAN GAME FISHES. By Francesca LaMont. Doubleday and Company, Inc., New York. XIV + 202. 73 Plates. $3.00.—This guide to fresh and salt water game fishes of North America is a handy pocket field manual. It is especially designed for the use of the fisherman who wants to name a fish he has caught. However, fishery biologists and specialists in other fields are often called upon to identify fish for sportsmen and they will therefore find it useful.

In the Introduction Miss LaMonte defines the term *game fish*, discusses common and scientific names, identification, the uncertainties of the use of color as a distinguishing character, etc. The book consists of two parts, dividing the salt and fresh water species.

Tables of data on record of salt and fresh water fish caught by anglers and a key to the identification of the groups of fish are appended. The species are grouped according to their taxonomic relations. Each group is briefly described. The most generally accepted common name is given followed by the scientific name. Other common names are listed. Various facts concerning the distribution, color, distinguishing characters, size, food and habits are also given. The book is excellently illustrated; 81 fish are shown in color, 72 in black and white.—C. M. MOTTLEY, *Fish and Wildlife Service, Washington, D.C.*

EDITORIAL NOTES AND NEWS

Wildlife Conference

THE twelfth NORTH AMERICAN WILDLIFE CONFERENCE will be held in San Antonio, Texas, February 3, 4 and 5, 1947. This is the first time the annual meeting has been called in the southwest and it is hoped that there will be an unusually large attendance from the middle west, western and southern states, and Mexico. DR. GABRIELSON, President of the Wildlife Management Institute, points out that there is special need for this conference to co-ordinate the efforts of all agencies and groups in the replenishment of renewable natural resources in North America, diminished by the war years. Incentives for wildlife and the more lasting benefits of good land use will be stressed.

Adequate hotel accommodations have been reserved for the 1947 conference.

News Notes

PROFESSOR J. R. DYMOND, Director of the Royal Ontario Museum of Zoology, Toronto, attended the meeting of the International Council for the Exploration of the Sea, in Stockholm, from August 12 to 19, 1946, as official observer for the Canadian Department of Fisheries. He reports that enroute he visited the British Museum (Natural History) and met DR. ETHELWYNN TREWAVAS and DR. TCHERNAVIN. The British delegation, which he accompanied to and from Stockholm, included SIR D'ARCY THOMPSON, DR. E. S. RUSSELL, DR. F. S. RUSSELL, MICHAEL GRAHAM and W. C. HODGSON. Among European ichthyologists attending the Stockholm meeting were DR. A. V. TANING, KNUT DAHL, EINAR LEA, DR. ORVAR NYBELIN, DR. K. A. ANDERSSON, DR. GUNNAR ALM and DR. JOHAN HJORT.

MAJOR L. D. BRONGERSMA, D.Sc., K.N.I.A., has returned to Leiden after an absence of nine months in Malaya and Java.

DR. KENNETH D. CARLANDER is back from the service and is now Assistant Professor of Zoology at Iowa State College (Ames), where he is carrying on fisheries work.

MR. LUIS RENÉ RIVAS of Cuba has been granted a year's extension of his Guggenheim fellowship and is working this year on West Indian fishes, in the American Museum, Museum of Comparative Zoology, Stanford University and Scripps Institution of Oceanography.

DR. MILNER B. SCHAEFER is back in civilian life after a period of service in the U.S. Navy. He is with the Fish and Wildlife Service, attached to the South Pacific Investigations and stationed at Stanford University.

DR. CURTIS L. NEWCOMBE has resigned as Director of the Virginia Fisheries Laboratory, Williamsburg, to join the staff of Cranbrook Institute of Science as Zoologist.

Naturalists' Directory

OF ESPECIAL interest to naturalists is THE NATURALISTS' DIRECTORY, which contains names, addresses and special subjects of study of professional and amateur naturalists throughout the world. A new edition was published in September, 1946, price $3.00 postpaid.

A. S. I. & H. Meetings THE MICHIGAN DEPARTMENT OF CONSERVATION will be host for the 1947 meetings of the AMERICAN SOCIETY OF ICHTHYOLOGISTS AND HERPETOLOGISTS, to be held at the Higgins Lake State Training School, near Roscommon, in the resort area of the northern portion of the Lower Peninsula, August 28–30. The AMERICAN SOCIETY OF MAMMALOGISTS will meet at Higgins Lake August 25–27.

INDEX TO SCIENTIFIC NAMES
1946, NOS.1-4

New names and their principal references are printed in bold face type.

Abramis ballerus, 24
  brama, 25
Acanthocybium solandri, 84
Acanthurus bahianus, 175
aceraensis, Phrynobatrachus, 15–16
Achirus fasciatus, 263
Acipenser ruthenus, 26
  stellatus, 25
Acris, 253
  crepitans, 44, 253
  gryllus, 253
    crepitans, 253
acuminatus, Oxybelis, 108
acutus, Crocodylus, 13, 152
  Fodiator, 189
adspersus, Tautogolabrus, 136
Aeginella longicornis, 137
aestivus, Opheodrys, 44, 73
affinis, Cypselurus, 193
  Hirundichthys, 193, 206
  Upogebia, 135
Agkistrodon, 150–51
  mokeson austrinus, 44, 74
    laticinctus, 242, 246
    mokeson, 242–44, 246–47
  piscivorus, 242, 244–46
    leucostoma, 44
    piscivorus, 74
albilabris, Leptodactylus, 51
albonotatus, Physalaemus, 154
albopunctatus, Chiasmocleis, 154
Alligator, 149–50
  mississipiensis, 74
  thompsoni, 150
Allogambusia tridentiger, 21–22
Allophallus kidderi, 21–22
altipinnis, Notropis, 79
altus, Pseudopriacanthus, 175
amabilis, Diadophis, 70
Ambloplites cavifrons, 220
Ambystoma opacum, 106
  tigrinum mavortium, 51
    tigrinum, 51
Ameiurus, 46, 263
  melas, 46, 86
Ameiva exsul, 51
amentus, Esox, 43
americana, Mysis, 134, 136–37, 139, 141–42
americanus, Bufo americanus, 44, 107
  Bufo terrestris, 107
amoena, Carphophis amoena, 48
Ampelisca, 134, 137, 139
Amphisbaena leucura, 16
Amyda, 46
  emoryi, 46
  sinensis, 249
Anchoviella, 23
Andrias scheuchzeri, 149
Aneides ferreus, 45
  flavipunctatus, 45
Anguilla rostrata, 137
Anhinga, 17
Anolis, 1
  carolinensis, 73
  chrysolepis, 108
  cristatellus, 50
  pulchellus, 50
Anoptichthys jordani, 86, 88–89
antillensis, Eleutherodactylus, 51
Aphredoderus, 263
  sayanus, 263
Aplodinotus grunniens, 263
Arbutus menziesii, 159
Archomenella pinguis, 137
arenarius, Haustorius, 134
arnyi, Diadophis punctatus, 44
asper, Engyrus, 11
Aspius aspius, 24
aspius, Aspius, 24
Assellus, 49
Astyanax mexicanus, 88
atlanticus, Tarpon, 175
Atractus trilineatus, 108
atricaudatus, Crotalus horridus, 74
atromaculatus, Semotilus atromaculatus, 226
atrorus, Schilbeodes marginatus, 226
atrox, Crotalus, 242, 244, 247–48
attenuatus, Batrachoseps attenuatus, 45
auduboni, Sylvilagus, 64, 70
Aulophallus, 23
  elongatus, 20–23
auratus, Carassius, 85
austrinus, Agkistrodon mokeson, 44, 74

bahianus, Acanthurus, 175
baileyi, Crotaphytus collaris, 257
ballerus, Abramis, 24
barbatulus, Nemachilus, 88
barbatus, Sus, 48

Barbourisia, 41–42, 260–62
rufa, 41, 260
Barbus capito, 25
Batrachoseps attenuatus attenuatus, 45
bartramia, Hyla crucifer, 103
beecheyi, Citellus, 64, 70
belizanus, Belonesox, 21–23
Belone belone, 191
belone, Belone, 191
Belonesox belizanus, 21–23
Benthoscopus, 42
laticeps, 42
Berberis, 159
bilinearis, Merluccius, 136
bimaculata, Elaphe, 251–52
bimaculatus, Pseudoxiphophorus, 21–22
bislineata, Eurycea bislineata, 106
bispinosus, Diastylis, 139
blainvillii, Phrynosoma, 64
Boleosoma podostemone, 220
borealis, Cancer, 139
bottae, Charina, 158
Thomomys, 64, 70
boutoni, Cryptoblepharus, 258
boylii, Peromyscus, 64
brachiopterus, Exocoetus, 210
Brachypleura, 97
Brachyrhaphis cascajalensis, 21–22
episcopi, 21–22
terrabensis, 21–22
brama, Abramis, 25
braminus, Typhlops, 101
bubalus, Ictiobus, 263
Bufo, 149
americanus americanus, 44, 107
granulosus, 143–54
marinus, 108, 153–54
paracnemis, 153–54
terrestris, 72, 107
americanus, 107
copei, 107
terrestris, 107
woodhousii, 256
Bungarus multicinctus multicinctus, 252
wanghotingi, 252
butleri, Thamnophis, 106

caeca, Chirodotea, 137
Calappa, 175
californica, Lophortyx, 65, 70
californicus, Cheilopogon, 192, 206, 208, 213
Cypselurus, 188–98, 200–13
Cypsilurus, 196, 208–209
Exocoetus, 208
Microtus, 64, 70
Perognathus, 64
Callechelys, 175
Callinectes sapidus, 263
Cambaroides, 145
Cambarus, 145
Cancer borealis, 139
capito, Barbus, 25
Caranx guara, 259
Carassius auratus, 85
Carcharinus milberti, 174–75
obscurus, 174–75
Cardium pinnulatum, 137
carinatus, Engyrus, 10–11
carolina, Terrapene, 173
carolinensis, Anolis, 73
Gastrophryne, 44, 72
carolinus, Prionotus, 118–21, 123–37, 139–42
Carphophis amoena amoena, 48
vermis, 44
carpio, Cyprinus, 25, 263
cascajalensis, Brachyrhaphis, 21–22
caspica, Clemmys, 150
caspius, Salmo trutta, 25
Castilleja, 159
catenatus, Sistrurus catenatus, 242–43, 245–46, 248
catenifer, Pituophis, 70
catesbeiana, Rana, 44, 72
Catonotus flabellaris, 226
Catostomus commersonnii commersonnii, 226
caudimaculatus, Hemiexocoetus, 189
Causus rhombeatus, 17
cavifrons, Ambloplites, 220
Cemophora coccinea, 73
centrata, Malaclemmys terrapin, 171–72
Centropages hamatus, 136
cepedianum, Dorosoma, 263
Cephalacanthus volitans, 140
cephalus, Mugil, 263
Cerapus tabularis, 137–38
cerasinus, Notropis, 226
cervinum, Moxostoma, 218–19, 224
Cervus hippelaphus, 17
Cetostomus, 262
regani, 262
Cetomimus, 41, 262
Chaenobryttus coronarius, 263
Channa orientalis, 41
Charina, 158–59
bottae, 158
Cheilopogon, 205, 207–208, 210–13
californicus, 192, 206, 208, 213
pinnatibarbatus, 206, 208, 211
solandri, 206
Chelonia mydas, 48
Chelydra, 151
serpentina serpentina, 44, 173
Chiasmocleis albopunctatus, 154
Chilopogon, 207
chinensis, Eumeces chinensis, 250
Chirodotea caeca, 137
chittendeni, Cyclopsetta, 28
Chrosomus oreas, 226
Chrysemys picta marginata, 255
chrysolepis, Anolis, 108
cinerea, Formica, 145
Hyla cinerea, 72
cinereus, Plethodon cinereus, 106, 169
cirriger, Cypselurus, 210, 213
Exocoetes, 207, 210
Exonautes, 210
Ptenonotus, 210

Citellus beecheyi, 64, 70
spilosoma, 51
Citharichthys macrops, 175
clamitans, Rana, 44, 72, 237
Clemmys, 150
caspica, 150
leprosa, 150
marmorata, 150
Clevelandia ios, 113, 116
Clinostomus vandoisulus, 226
Clupea harengus, 136
clupeaformis, Coregonus, 43
Cnemidophorus, 173
sexlineatus, 44, 73
tessellatus, 64, 70
tessellatus, 257
Cobitis taenia, 262
coccinea, Cemophora, 73
coenosus, Pleuronichthys, 196
cognatus, Cottus, 100
Cololabis saira, 193, 197
Coluber constrictor constrictor, 48, 73, 243, 245
mormon, 159
lateralis, 70
comatus, Cypselurus, 192, 206
commersonii, Hemiramphus, 192
Commersonnii, Exocaetus, 212
commersonnii, Catostomus commersonnii, 226
constrictor, Coluber constrictor, 48, 73, 243, 245
contortrix, Heterodon, 47–48, 75, 77, 243
Heterodon contortrix, 44, 73
copei, Bufo terrestris, 107
coregoni, Echinorhynchus, 235
Coregonus, 148
clupeaformis, 43
coromandulensis, Cypselurus, 192
Hirundichthys, 192
coronarius, Chaenobryttus, 263
Coryphaena hippurus, 81, 84
Cottus cognatus, 100
Crago, 140
septemspinosus, 135, 137–42
crassus, Triaenophorus, 235
crepitans, Acris, 44, 253
Acris gryllus, 253
cristatellus, Anolis, 50
Crocodylus, 151–52
acutus, 13, 152
novae-guineae, 17–20
porosus, 18–20, 152
Crotalus atrox, 242, 244, 247–48
horridus atricaudatus, 74
horridus, 242–43, 245, 247
molossus, 247
viridis lutosus, 257
oreganus, 64, 70
Crotaphytus collaris baileyi, 257
wislizenii, 257
crucifer, Hyla crucifer, 103
Cryptoblepharus, 258
boutoni, 258
Cryptobranchus, 149
cuvier, Galeocerdo, 174
cyanellus, Lepomis, 263
cyanopterus, Cypselurus, 206
Cyathocephalus, 235
Cyclopsetta, 28
chittendeni, 28
decussata, 27
fimbriata, 28
querna, 27–28
Cynoscion, 263
nebulosus, 263
Cyprinodon, 41
Cyprinus carpio, 25, 263
Cypselurus, 189, 191, 193–94, 204–205, 207–208, 210, 212–13
affinis, 193
californicus, 188–98, 200–13
cirriger, 210, 213
comatus, 192, 206
coromandulensis, 192
cyanopterus, 206
exsiliens, 206
furcatus, 206, 212
heterurus, 192, 194–95, 206, 208
lineatus, 211–13
lutkeni, 192, 206
minos, 211
new species, 193, 196, 209
pinnatibarbatus, 206, 208, 210–13
pulchellus, 217, 211–12
solandri, 206, 210–11, 213
speculiger, 188–89, 206
Cypsilurus, 205, 210
californicus, 196, 208–209

daemeli, Rana, 18
Danichthys, 204–205, 213
rondeletii, 189, 192, 194, 206
rufipinnis, 209
Darienichthys dariensis, 21–22
dariensis, Darienichthys, 21–22
Dasyatis guttatus, 43
latus, 43
decussata, Cyclopsetta, **27**
dekayi, Storeria, 244, 246–47
Demansia olivacea, 18
dentatus, Paralichthys, 86
deserticola, Pituophis catenifer, 257
Desmognathus fuscus fuscus, 48
Devisia, 151
Diadophis amabilis, 70
punctatus arnyi, 44
edwardsii, 47
punctatus, 73
diaphanus, Fundulus diaphanus, 79
Diastylis, 134, 137–38
bispinosus, 139
Dicamptodon, 45
Dinematichthys iluocoeteoides, 92, 95
Dinodon rufozonatum, 251
dione, Elaphe, 251–52
Dipodomys heermanni, 64, 70
Dipsosaurus dorsalis dorsalis, 172
directus, Ensis, 139
Ditropichthys, 41, 262

divaricata, Larrea, 172
Dormitator, 263
maculatus, 263
Dorosoma cepedianum, 263
dorsalis, Dipsosaurus dorsalis, 172
douglassii, Phrynosoma douglassii, 257
dovii, Gambusia, 21–22
dubius, Thorius, 45
dumerili, Seriola, 83, 259

Echinorynchus coregoni, 235
edwardsii, Diadophis punctatus, 47
Monoculodes, 137
Egretta, 18
Elachistocleis ovale, 154
Elaphe, 150–51, 161–62, 164–67, 170
bimaculata, 251–52
dione, 251–52
guttata, 73–74, 167
obsoleta obsoleta, 44, 48, 102, 160, 163–64, 167, 243, 245
elegans, Psammophis, 16
Turbonilla, 139
Eleutherodactylus antillensis, 51
latrans, 173
urichi, 108
elongata, Hyla, 153
elongatus, Aulophallus, 20–23
Gnathagnus, 42
Plethodon, 45
Elops, 263
saurus, 263
emoryi Amyda, 46
Emydura, 18
Emys, 148, 150
orbicularis, 150
Engyrus, 10
asper, 11
carinatus, 10–11
Ensatina eschscholtzii, 45
eschscholtzii, 45
picta, 45
Ensis directus, 139
Epinephelus morio, 175
episcopi, Brachyrhaphis, 21–22
erinacea, Raja, 140
erythrocephalus, Theotops, 145
erythrogaster, Natrix erythrogaster, 44, 256
erythrophthalmus, Scardinius, 24–25
eschscholtzii, Ensatina, 45
Ensatina eschscholtzii, 45
Esox amentus, 43
immaculatus, 43
lucius, 88, 148
Eumeces, 150
chinensis chinensis, 250
fasciatus, 44, 73
gilberti, 70
skiltonianus, 148
Eupemphix nattereri, 154–55
pustulosus trinitatis, 108
Eurycea bislineata bislineata, 106
longicauda longicauda, 169
melanopleura, 106
lucifuga, 106
Eutamias merriami, 64
Euthynnus yaito, 84
evolans, Prionotus, 119
Prionotus evolans, 119
Exocaetus Commersonnii, 212
Exocoetus, 191, 195, 207
brachiopterus, 210
californicus, 208
cirriger, 207, 210
furcatus, 211
furcorum, 211–12
heterurus, 192
lineatus, 211–12
obtusirostris, 191
pinnatibarbatus, 211–12
rostratus, 189
solandri, 210
spilurus, 211
volitans, 191, 194–95
Exonautes, 204
cirriger, 210
rondeletii, 189
exsiliens, Cypselurus, 206
exsul, Ameiva, 51

falcata, Seriola, 259–60
falcatus, Zonichthys, 259
far, Hemiramphus, 192
fasciata, Natrix sipedon, 73, 256
fasciatus, Achirus, 263
Eumeces, 44, 73
Sceloporus undulatus, 44, 47, 265
femoralis, Hyla, 72
feriarum, Pseudacris, 257
ferreus, Aneides, 45
fimbriata, Cyclopsetta, 28
flagellaris, Catonotus, 226
flagellum, Masticophis flagellum, 73
flavilata, Rhadinaea, 73
flavipunctatus, Aneides, 45
Fodiator acutus, 189
pacificus, 189
rostratus, 189, 192
Formica cinerea, 145
rufibarbis, 145
formosa, Heterandria, 20–23
fowleri, Bufo woodhousii, 44, 48, 104
frisii, Rutilus, 24
fulvius, Micrurus, 73
Micrurus fulvius, 74
Fundulus diaphanus diaphanus, 79
heteroclitus macrolepidotus, 79
furcatus, Cypselurus, 206, 212
Exocoetus, 211
Ictalurus, 263
furcorum, Exocoetus, 211–12
fuscipes, Neotoma, 64, 70
fuscomaculatus, Physalaemus, 154
fuscus, Desmognathus fuscus, 48
Papilo, 65, 70

gachua, Ophicephalus, 41
Galeocerdo cuvier, 174
Gallinula, 17

Gambusia affinis holbrookii, 21–22
dovii, 21–22
nobilis nobilis, 21–22
Gammarus locusta, 134, 137, 139, 141–42
garnotii, Hemidactylus, 4, 9, 45
Gastrophryne carolinensis, 44, 72
Gehyra oceanica, 101, 104
Geoclemmys reevesi, 249
Geoemyda, 151
geographica, Graptemys, 168, 171
georgii, Hemiramphus, 192
Gerrhonotus, 155–56, 159
coeruleus principis, 155
multicarinatus, 64
webbii, 105
getulus, Lampropeltis getulus, 47
gibbifrons, Prognichthys, 192, 206
gilberti, Eumeces, 70
Ilypnus, 116
Schilbeodes, 220
glanis, Silurus, 24
glutinosus, Plethodon glutinosus, 44, 106–107
Gnathagnus, 42
elongatus, 42
innotabilis, 42
laticeps, 42
Gonatodes humeralis, 108
vittatus, 108
Gordichthys, 175
Gordius, 234
gracilentus, Neacanthopsis, 262
gracilis, Physalaemus, 154
graciosus, Sceloporus graciosus, 257
grandicornis, Scorpaena, 175
granulosus, Bufo, 153-54
Triturus granulosus, 45
Graptemys geographica, 168, 171
griseus, Sciurus, 64
grunniens, Aplodinotus, 263
gryllus, Acris, 253
guara, Caranx, 259
gurnardus, Trigla, 124
guttata, Elaphe, 73–74, 167
guttatus, Dasyatis, 43
Gyrinomimus, 41–42, 116, 262
myersi, 116–17
simplex, 116, 117

hamatus, Centropages, 136
hamiltoni, Thoburnia, 218, 219, 220–23
hammondii, Scaphiopus, 70
harengus, Clupea, 136
Haustorius arenarius, 134
heermanni, Dipodomys, 64, 70
Heloderma, 151
Hemidactylus, 4, 6–7, 9
garnotii, 4, 9, 45
Hemiexocoetus, 190
caudimaculatus, 189
Hemiramphus, 191, 208, 213
commersonii, 192
far, 192
georgii, 192
krysnaensis, 192
marginatus, 192
Hepatus, 175
Heterandria, 23
formosa, 20–23
Heterodon, 75, 78
contortrix, 47–48, 75, 77, 243
contortrix, 44, 73
Heterostichus rostratus, 190
heterurus, Cypselurus, 192, 194–95, 206, 208
Exocoetus, 192
hippelaphus, Cervus, 17
Hippoglossus hippoglossus, 100
hippoglossus, Hippoglossus, 100
hippurus, Coryphaena, 81, 84
Hirundichthys, 204–205, 207–208, 213
affinis, 193, 206
coromandelensis, 192
speculiger, 188–89, 206
hispidus, Sauromalus, 254
Histrio, 193
holbölli, Phoxocephalus, 134, 137
holbrooki, Lampropeltis getulus, 44
holbrookii, Gambusia affinis, 21–22
Scaphiopus holbrookii, 72
horridus, Crotalus horridus, 242–43, 245, 247
humeralis, Gonatodes, 108
Huro salmoides, 263
hyacinthinus, Sceloporus undulatus, 265
Hydnophytum, 258
Hydromantes, 145, 151
Hyla, 103, 145, 149
cinerea cinerea, 72
crucifer bartramia, 103
crucifer, 103
elongata, 153
femoralis, 72
infrafrenata, 18
mcgregori, 18, 258
nana, 153
nasica, 153
nasuta, 18
regilla, 257
rubra, 153
spegazzinii, 153
squirella, 72
venulosa, 153
versicolor versicolor, 72
Hylarthroleptis, 15
Hypentelium nigricans, 226
Hypopachus incrassatus, 154
Hypsiglena, 157-58
ochrorhyncha, 76, 157

Ictalurus, 46
furcatus, 263
punctatus, 263
Ictiobus bubalus, 263
Iguana iguana, 50
iguana, Iguana, 50
iluocoeteoides, Dinematichthys, 92, 95
Ilypnus gilberti, 116
immaculatus, Esox, 43
incrassatus, Hypopachus, 154

infans, Poeciliopsis, 21–22
infrafrenata, Hyla, 18
innotabilis, Gnathagnus, 42
inornatus, Perognathus, 64
intermontanus, Scaphiopus hammondii, 256
interrupta, Morone, 263
ios, Clevelandia, 113, 116
Irediparra, 17
irrorata, Unicola, 134, 137, 139

jordani, Anoptichthys, 86. 88–89
Plethodon, 102

Kathetostoma, 42
Katsuwonus pelamis, 81–83
kidderi, Allophallus, 21–22
Kinosternon subrubrum subrubrum, 74
krysnaensis, Hemiramphus, 192

Labidesthes, 193
lacustris, Salmo, 88
lalandi, Seriola, 259
Lampropeltis, 70
getulus getulus, 47
holbrooki, 44
triangulum syspila, 44
triangulum, 245, 247-48
Lanthanotus, 151
Larrea divaricata, 172
laterale, Leiolopisma, 44, 149
lateralis, Coluber, 70
Natrix tigrina, 250
laticeps, Benthoscopus, 42
Gnathagnus, 42
laticinctus, Agkistrodon mokeson, 242, 246
latrans, Eleutherodactylus, 173
latus, Dasyatis, 43
Lebistes reticulatus, 21
Leiolopisma, 150–51
laterale, 44, 149
modestum, 149
septentrionale, 149
Lepidoblepharon, 97
opthalmolepis, 97
Lepidochelys olivacea, 103
Lepidodactylus, 6
lugubris, 4, 8–9
Lepisosteus, 100
osseus leptorhynchus, 263
oxyurus, 100
platostomus, 263
spatula, 263
Lepomis cyanellus, 263
macrochirus, 263
leprosa, Clemmys, 150
leptocephalus, Nocomis, 226
Leptodactylus albilabris, 51
petersi, 108
leptorhynchus, Lepisosteus osseus, 263
leucichthys, Stenodus, 25
leucostoma, Agkistrodon piscivorus, 44
leucura, Amphisbaena, 16
lineatus, Cypselurus, 211–13
Cypsilurus, 211
Exocoetus, 211–12
littoralis, Malaclemmys terrapin, 171–72
Parexocoetus brachypterus, 192, 194
locusta, Gammarus, 134, 137, 139, 141–42
longicarpus, Pagurus, 139
longicauda, Eurycea longicauda, 169
longicornis, Aeginella, 137
longirostris, Tylosurus, 192
Lophortyx californica, 65, 70
Lota lota, 24, 148
lota, Lota, 24, 148
lucifuga, Eurycea, 106
Lucioperca lucioperca, 24
volgensis, 24
lucioperca, Lucioperca, 24
lucius, Esox, 88, 148
lugubris, Lepidodactylus, 4, 8–9
Lupinus, 159
lutkeni, Cypselurus, 192, 206
lutosus, Crotalus viridis, 257

macrocephala, Tilapia, 88
macrochirus, Leopomis, 263
Macrocystis pyrifera, 190
macrolepidotus, Fundulus heteroclitus, 79
macrolepis, Sphaerodactylus, 50
macrops, Citharichthys, 175
macropterus, Neothunnus, 84
macrospilota, Malaclemmys terrapin, 171–72
macrostemma, Thamnophis, 106
maculatus, Dormitator, 263
Pseudupeneus, 175
mairii, Natrix, 18
Malaclemmys [Malaclemys], 171
littoralis rhizophorarum, 171
pileata, 171
terrapin, 171
centrata, 171–72
littoralis, 171–72
macrospilota, 171–72
pileata, 172
rhizophorarum, 172
terrapin, 172
maniculatus, Peromyscus, 64
marcianus, Thamnophis, 106
marginata, Chrysemys picta, 255
Rissoula, 175
marginatus, Hemiramphus, 192
marina, Strongylura, 192
marinus, Bufo, 108, 153–54
Tylosurus, 192
marmorata, Clemmys, 150
Masticophis flagellum flagellum, 73
mavortium, Ambystoma tigrinum, 51
mcgregori, Hyla, 18, 258
Megalobatrachus, 149
megalotis, Reithrodontomys, 64
Melaleuca, 17, 19
melanogenion, Parexocoetus, 208
Ptenonotus, 208
melanopleura, Eurycea longicauda, 106
melanotus, Tylosurus, 191
melas, Ameiurus, 46, 86
menziesii, Arbutus, 159
meridionalis, Takydromus sexlineatus, 250
Merluccius bilinearis, 136

merriami, Eutamias, 64
mesogaster, Parexocoetus, 192
metcalfi, Plethodon, 102, 174
mexicanus, Astyanax, 88
Michtheimysis stenolepis, 134, 139
microlepis, Mycteroperca, 175
Micropogon, 263
  undulatus, 263
micropterus, Oxyporhamphus micropterus, 191
Microtus californicus, 64, 70
  pennsylvanicus pennsylvanicus, 64
Micrurus, 74
  fulvius, 73
    fulvius, 74
milberti, Carcharinus, 174–75
miliarius, Sistrurus miliarius, 73
minos, Cypselurus, 211
minutus, Pseudocalanus, 136
mississipiensis, Alligator, 74
mitchelli, Anchoviella, 23
modestum, Leiolopisma, 149
mokeson, Agkistrodon mokeson, 242–44, 246–47
Mollienisia sphenops, 21–22
  velifera, 21–22
molossus, Crotalus, 247
Monoculodes edwardsii, 137
montanus, Pseudotriton montanus, 105, 168
mordax, Osmerus, 23
morio, Epinephelus, 175
mormon, Coluber constrictor, 159
Morone, 263
  interrupta, 263
Moxostoma cervinum, 218–19, 224
  rupiscartes, 224
Mugil cephalus, 263
multicarinatus, Gerrhonotus, 64
multicinctus, Bungarus multicinctus, 252
Mus musculus, 48, 64, 159
musculus, Mus, 48, 64, 159
mutilatus, Peropus, 4
Mycteroperca microlepis, 175
  venenosa, 175
mydas, Chelonia, 48
myersi, Gyrinomimus, 116–17
myops, Trachinocephalus, 175
Mysis americana, 134, 136–37, 139, 141–42
  relicta, 234

nana, Hyla, 153
nasica, Hyla, 153
nasuta, Hyla, 18
Natrix, 150, 162, 164–67
  erythrogaster erythrogaster, 44, 256
  mairii, 18
  popei, 250
  rhombifera rhombifera, 263
  sipedon fasciata, 73, 256
    pictiventris, 256
    pleuralis, 255–56
    sipedon, 44, 47, 160, 164, 245–46, 255–56
  stolata, 250
  taxispilota, 73
  tigrina lateralis, 250
nattereri, Eupemphix, 154–55
Neacanthopsis gracilentus, 262
nebulosus, Cynoscion, 263
Necturus, 149
Nemachilus barbatulus, 88
Neothunnus macropterus, 84
Neotoma fuscipes, 64, 70
nigricans, Hypentelium, 226
nigro-maculatus, Pomoxis, 263
nitidus, Philothamnus semivariegatus, 16
nobilis, Gambusia nobilis, 21–22
Nocomis leptocephalus, 226
nodulosus, Triaenophorus, 235
Norops ophiolepis, 50
notatus, Tylosurus, 192
Notropis altipinnis, 79
  cerasinus, 226
  scepticus, 79
novae-guineae, Crocodylus, 17–20
Nucula, 137

obscurus, Carcharinus, 174–75
obsoleta, Elaphe obsoleta, 44, 48 102, 160, 163–64, 167, 243, 245
obtusirostris, Exocoetus, 191
occidentalis, Poeciliopsis, 21–22
  Sceloporus, 64, 70
  Sceloporus occidentalis, 159
occipitalis, Rana, 15
occipitomaculata, Storeria, 47
  Storeria occipitomaculata, 73
oceanica, Gehyra, 101, 104
ochrorhyncha, Hypsiglena, 76, 157
Odostomia, 135
olivacea, Demansia, 18
  Lepidochelys, 103
  Pelomedusa subrufa, 16
olympicus, Rhyacotriton, 45
opacum, Ambystoma, 106
Opheodrys, 150
  aestivus, 44, 73
Ophicephalus gachua, 41
ophiolepis, Norops, 50
Ophisaurus, 150–51
  ventralis, 73
opthalmolepis, Lepidoblepharon, 97
orbicularis, Emys, 150
ordinoides, Thamnophis, 70
oreas, Chrosomus, 226
oreganus, Crotalus viridis, 64, 70
orientalis, Channa, 41
Osmerus mordax, 23
ovale, Elachistocleis, 154
Oxybelis acuminatus, 108
Oxyporhamphus, 191
  micropterus micropterus, 191
    similis, 191
oxyrhynchus, Rana oxyrhynchus, 15
oxyurus, Lepisosteus osseus, 100

pacificus, Fodiator acutus, 189
Pagurus longicarpus, 139
Palaemonetes vulgaris, 140
palustris, Rana, 44
papillosum, Syacium, 175
Papilo fuscus, 65, 70

papuensis, Sus, 17–18
paracnemis, Bufo, 153–54
paradoxa, Pseudis, 154
Paralichthys dentatus, 86
Paraphoxus spinosus, 137
Parexocoetoides, 204, 207, 211, 213
  vanderbilti, 201–204, 207, 209, 213
Parexocoetus, 195
  brachypterus littoralis, 192, 194
  melanogenion, 208
  mesogaster, 192
pelagicus, Syngnathus, 259
Pelamis platurus, 103
pelamis, Katsuwonus, 81–83
Pelecinomimus, 41, 262
Pelomedusa subrufa, 16
    olivacea, 16
pennsylvanicus, Microtis pennsylvanicus, 64
Perca, 148
Percina rex, 220
Perognathus, 70
  californicus, 64
  inornatus, 64
Peromyscus, 68, 70, 159
  boylii, 64
  maniculatus, 64
  truei, 64
Peropus, 6
  mutilatus, 4
petersi, Leptodactylus, 108
Phalacrocorax 17, 249
Philothamnus semivariegatus nitidus, 16
Phoxocephalus holbölli, 134, 137
Phrynobatrachus, 15
  aceraensis, 15–16
Phrynosoma blainvillii, 64
  douglassii douglassii, 257
  platyrhinos, 257
Physalaemus albonotatus, 154
  fuscomaculatus, 154
  gracilis, 154
Physignathus temporalis, 18
picta, Ensatina eschscholtzii, 45
pictiventris, Natrix sipedon, 256
pileata, Malaclemmys, 171
  Malaclemmys terrapin, 172
pinguis, Archomenella, 137
pinnatibarbatus, Cheilopogon, 206, 208, 211
  Cypselurus, 206, 208, 210–13
  Exocoetus, 211–12
pinnulatum, Cardium, 137
pipiens, Rana, 44, 257
Pipilo fuscus, 65, 70
piscivorus, Agkistrodon, 242, 244–46
  Agkistrodon piscivorus, 74
Pituophis, 159
  catenifer, 70
    deserticola, 257
  sayi sayi, 167
platostomus, Lepisosteus, 263
platurus, Pelamis, 103
platyrhinos, Phrynosoma, 257
Platysternon, 151
Plethodon cinereus cinereus, 106, 169
  elongatus, 45
  glutinosus glutinosus, 44, 106–107
  jordani, 102
  metcalfi, 102, 174
  richmondi, 169
  welleri, 174
pleuralis, Natrix sipedon, 255–56
Pleuronichthys, 196
  coenosus, 196
pleurospilus, Poecilistes, 21–22
Podiceps, 17
podostemone, Boleosoma, 220
Poecilia vivipara, 21
Poeciliopsis infans, 21–22
  occidentalis 21–22
Poecilistes pleurospilus, 21–22
Polyodon, 149
Pomoxis nigro-maculatus, 263
Pontoporeia, 234
popei, Natrix, 250
porosus, Crocodylus, 18–20, 152
Porphyrio, 17
Potamobius, 145
principis, Gerrhonotus coeruleus, 155
Prionotus, 119, 121–22, 124, 136, 141
  carolinus, 118–21, 123–37, 139–42
  evolans, 119
    evolans, 119
    strigatus, 118–25, 127, 130–33, 136, 139–42
  strigatus, 119
Prognichthys, 189, 194, 204–205, 208, 213
  gibbifrons, 192, 206
  rondeletii, 189, 192, 194–95, 206
Psammophis elegans, 16
  sibilans sibilans, 16
Psephurus, 149
Pseudacris, 255–58
  feriarum, 257
  nigrita triseriata, 244, 257–58
Pseudemys, 151
  scripta troosti, 263
Pseudis, 153–54
  paradoxa, 154
Pseudocalanus minutus, 136
Pseudopriacanthus altus, 175
Pseudotriton montanus montanus, 105, 168
Pseudoxiphophorus bimaculatus, 21–22
Pseudupeneus maculatus, 175
Ptenonotus, 217, 210–11, 213
  cirriger, 210
  melanogenion, 208
Pterophryne, 193
pulchellus, Anolis, 50
  Cypselurus, 207, 211–12
punctatus, Diadophis punctatus, 73
  Ictalurus
pyrifera, Macrocystis, 190

querna, Cyclopsetta, 27–28
Quietula y-cauda, 116

radix, Thamnophis, 106, 237
Raja erinacea, 140
Rana, 149
  catesbeiana, 44, 72
  clamitans, 44, 72, 237
  daemeli, 18

occipitalis, 15
oxyrhynchus oxyrhynchus, 15
palustris, 44
pipiens, 44, 257
sphenocephala, 72
raphidoma, Tylosurus, 203
rapicaudus, Thecadactylus, 108
reevesi, Geoclemmys, 249
regani, Cetostomus, 262
regilla, Hyla, 257
Reithrodontomys megalotis, 64
relicta, Mysis, 234
reticulatus, Lebistes, 21
rex, Percina, 220
Rhadinaea flavilata, 73
Rhipidura, 18
Rhizophora, 171
rhizophorarum, Malaclemmys littoralis, 171
Malaclemmys terrapin, 172
rhombeatus, Causus, 17
rhombifera, Natrix rhombifera, 263
rhothoeca, Thoburnia, 218-25
Rhyacotriton olympicus, 45
richmondi, Plethodon, 169
Rissola marginata, 175
rivoliana, Seriola, 259
Rondeletia, 262
rondeletii, Danichthys, 189, 192, 194, 206
Exonautes, 189
Prognichthys, 189, 192, 194-95, 206
Scomberesox, 193
rostrata, Anguilla, 137
rostratus, Exocoetus, 189
Fodiator acutus, 189, 192
Heterostichus, 190
rubra, Hyla, 153
Rubus ursinus, 159
rufa, Barbourisia, 41, 260
rufibarbis, Formica, 145
rufipinnis, Danichthys, 209
rufozonatum, Dinodon, 251
rupiscartes, Moxostoma, 224
ruthenus, Acipenser, 26
ruthveni, Thamnophis, 106
Rutilus frisii, 24
rutilus, 24–25
rutilus, Rutilus, 24–25

saira, Cololabis, 193, 197
Salmincola thymalli, 235
Salmo, 24
lacustris, 88
signifer, 227
trutta caspius, 25
salmoides, Huro, 263
sapidus, Callinectes, 263
Sauromalus, 254
hispidus, 254
saurus, Elops, 263
sayanus, Aphredoderus, 263
sayi, Pituophis sayi, 167
Scaphiopus, 72
hammondii, 70
intermontanus, 256
holbrookii, Scaphiopus holbrookii, 72
Scardinius erythrophthalmus, 24–25
Sceloporus, 159
graciosus graciosus, 257
occidentalis, 64, 70
occidentalis, 159
undulatus fasciatus, 44, 47, 265
hyacinthinus, 265
scepticus, Notropis, 79
scheuchzeri, Andrias, 149
Schilbeodes gilberti, 220
marginatus atrorus, 226
Sciurus griseus, 64
Scolecosaurus trinitatis, 108
Scolopendra, 49
Scomber scombrus, 136
Scomberesox rondeletii, 193
scombrus, Scomber, 136
Scorpaena grandicornis, 175
Semotilus atromaculatus atromaculatus, 226
septemspinosus, Crago, 135, 137–42
septentrionale, Leiolopisma, 149
Seriola, 259
dumerili, 83, 259
falcata, 259–60
lalandi, 259
rivoliana, 259
zonata, 259–60
serpentina, Chelydra serpentina, 44, 173
sexlineatus, Cnemidophorus, 44, 73
sibilans, Psammophis sibilans, 16
signifer, Salmo, 227
Silurus glanis, 24
similis, Oxyporhamphus, 191
simplex, Gyrinomimus, 116, 117
sinensis, Amyda, 249
sipedon, Natrix sipedon, 44, 47, 160, 164, 245–46, 255–56
sirtalis, Thamnophis, 70, 254
Thamnophis sirtalis, 44, 73, 106, 236, 243, 246
Sistrurus catenatus catenatus, 242–43, 245–46, 248
miliarius miliarius, 73
streckeri, 44
skiltonianus, Eumeces, 148
Sminthillus, 1
solandri, Acanthocybium, 84
Cheilopogon, 206
Cypselurus, 206, 210–11, 213
Exocoetus, 210
Solemya velum, 135
spatula, Lepisosteus, 263
speculiger, Cypselurus, 188–89, 206
Hirundichthys, 188–89, 206
spegazzinii, Hyla, 153
Sphaerodactylus, 1
macrolepis, 50
sphenocephala, Rana pipiens, 72
sphenops, Mollienisia, 21–22
spilosoma, Citellus, 51
spilurus, Exocoetus, 211
spinosus, Paraphoxus, 137
squirella, Hyla, 72
stansburiana, Uta, 64, 70
Uta stansburiana, 157, 257
stellatus, Acipenser, 25
Stenodus leucichthys, 25

stenolepis, Michtheimysis, 134, 139
stolata, Natrix, 250
Storeria dekayi, 244, 246–47
occipitomaculata, 47
occipitomaculata, 73
streckeri, Sistrurus miliarius, 44
strigatus, Prionotus, 119
Prionotus evolans, 118–25, 127, 130–33, 136, 139–42
Strongylura, 192
marina, 192
strongylurus, Tylosurus, 192
subrufa, Pelomedusa, 16
Sus barbatus, 48
papuensis, 17–18
subrubrum, Kinosternon subrubrum, 74
Syacium papillosum, 175
Sylvilagus auduboni, 64, 70
Syngnathus pelagicus, 259
syspila, Lampropeltis triangulum, 44

tabularis, Cerapus, 137–38
taenia, Cobitis, 262
Takydromus sexlineatus meridionalis, 250
Tarpon atlanticus, 175
Tautogolabrus adspersus, 136
taxispilota, Natrix, 73
Tellina, 135
tenera, 137
temporalis, Physignathus, 18
tenera, Tellina, 137
terrabensis, Brachyrhaphis, 21–22
Terrapene carolina, 173
triunguis, 173
terrapin, Malaclemmys, 171
Malaclemmys terrapin, 172
terrestris, Bufo, 72, 107
Bufo terrestris, 107
tessellatus, Cnemidophorus, 64, 70
Cnemidophorus tessellatus, 257
Thamnophis, 106, 167
butleri, 106
macrostemma, 106
marcianus, 106
ordinoides, 70
radix, 106, 237
ruthveni, 106
sirtalis, 70, 254
sirtalis, 44, 73, 106, 236, 243, 246
Thecadactylus rapicaudus, 108
Theotops erythrocephalus, 145
Thoburnia, 218–23
hamiltoni, 218, 219, 220–23
rhothoeca, 218–25
Thomomys bottae, 64, 70
thompsoni, Alligator, 150
Thorius dubius, 45
thymalli, Salmincola, 235
tigrinum, Ambystoma tigrinum, 51
Tilapia macrocephala, 88
Tmetonyx, 134
Trachinocephalus myops, 175
Triaenophorus crassus, 235
nodulosus, 235
triangulum, Lampropeltis triangulum, 245, 247–48
tridentiger, Allogambusia, 21–22
Trigla gurnardus, 124
trilineatus, Attractus, 108
Trimeresurus, 151
trinitatis, Eupemphix pustulosus, 108
Scolecosaurus, 108
Trionyx, 148, 150
triseriata, Pseudacris nigrita, 44, 257–58
Triturus, 149
granulosus granulosus, 45
viridescens viridescens, 48
triunguis, Terrapene, 44
troostii, Pseudemys scripta, 263
truei, Peromyscus, 64
Trygon tuberculata, 42
tuberculata, Trygon, 42
Turbonilla elegans, 139
Tylosurus, 191
longirostris, 192
marinus, 192
melanotus, 192
notatus, 192
raphidoma, 203
strongylurus, 192
Typhlops braminus, 101

Unciola irrorata, 134, 137, 139
undulatus, Micropogon, 263
Upogebia affinis, 135
Uranoscopus, 42
urichi, Eleutherodactylus, 108
ursinus, Rubus, 159
Uta, 157–58
stansburiana, 64, 70
stansburiana, 157, 257

vanderbilti, Parexocoetoides, 201–204, 207, 209, 213
vandoisulus, Clinostomus, 226
Varanus, 48
velifera, Mollienisia, 21–22
velum, Solemya, 135
venenosa, Mycteroperca, 175
ventralis, Ophisaurus, 73
venulosa, Hyla, 153
vermis, Carphophis amoena, 44
versicolor, Hyla versicolor, 72
viridescens, Triturus viridescens, 48
vittatus, Gonatodes, 108
vivipara, Poecilia, 21
volgensis, Lucioperca, 24
volitans, Cephalacanthus, 140
Exocoetus, 191, 194–95
vulgaris, Palaemonetes, 140

wanghotingi, Bungarus multicinctus, 252
webbii, Gerrhonotus multicarinatus, 105
welleri, Plethodon, 174
wislizenii, Crotaphytus, 257
woodhousii, Bufo, 256

yaito, Euthynnus, 84
y-cauda, Quietula, 116

zonata, Seriola, 259–60
Zonichthys falcatus, 259

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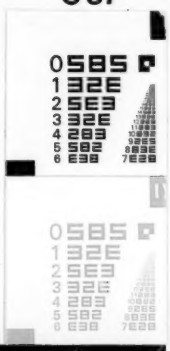
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